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PROCEEDINGS

OF

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

PITTSBURG, PA.

VOL. IV.

1888.

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CONTENTS.

VOL. IV.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

EIGHTH ANNUAL MEETING.

JANUARY 17TH, 1888.

Present—Forty-seven members and three visitors.
President Dempster in the chair.
Directors—Taylor, Hunt, Scaife and Phillips, all present.

Treasurer A. E. FROST reported:

Balance on hand, January 7, 1887,	$ 425 97	
Amount received in 1887, -	1,469 50	
		$1,895 47
Expenditures—		
Books, Periodicals, - - - -	$442 23	
Reporting, Printing and Postage,	579 37	
Rent, Furnishing and Expenses,	712 18	
		1,733 78
Balance to 1888, - - - - -		$161 69
Outstanding dues, $610.00		

Secretary WICKERSHAM reported—

Number of members, January 7, 1887, - -	304	
Admitted in 1887, - - - - - -	39	
		343
Members resigned in 1887, - - - -	12	
Lost by default, - - - - - -	1	
		13
Number of Members on Roll, January 7, 1888,		330

10 regular meetings were held during the year, which were attended by 322 members and 18 visitors, averaging 34 to a meeeting.

12 new papers were presented during the year, viz.:

Feb. 10. "High and Low Water Lines," T. P. Roberts.
"Specifications of the Keystone Bridge Company for Railroad Purposes," F. C. Osborn.

Mar. 15. "Comments on Specifications of Keystone Bridge Company's Specifications," Edwin Thecher.

May 17. "Fire Proof Buildings," L. O. Danse.

June 21. "Parallelometer," J. A. Brashear.

Sept. 20. "Pedestal of the Lick Telescope," J. A. Brashear.
"Our Society," T. P. Roberts.

Oct. 18. "Effect of Temperature on Iron and Steel," Jos. Ramsay, Jr.

Nov. 15. "Iron," T. P. Roberts.
"Some Tests of Steel Beams," C. P. Buchanan.

Dec. 21. "Iron and Steel as affected by Heat," Jos. Ramsay, Jr.
"Slide Moment Diagram," J. E. Greiner.
To be discussed hereafter.

F. C. PHILLIPS, from Library Committee, made the following report:

The work of the Library Committee during the year 1887 has been necessarily limited. No appropriations of a general character for new books has been made, and we cannot report any important purchases since the last annual meeting.

With periodical literature the library is well supplied, and the increased number of daily visitors, as shown by the Secretary's list, is evidence that the collection of journals is being more and more appreciated. It has been our aim to have all journals bound as soon as each volume is completed.

By a system of cards of invitation, recently adopted, members of the Society may now have the privileges of the library extended to their friends who may be visitors to the city. It is believed that in this manner the usefulness of the rooms is likely to be considerably increased.

For the purpose of facilitating references, a drawer catalogue is now in course of preparation, which will contain a complete alphabetical list of all books and pamphlets in the library.

Many important technical works have appeared since the foundation of the library, and the committee recommend that an effort be made as early as possible to increase the valuable collection already owned by the Society.

The retiring President read the following address:

To the Members of the Engineers' Society of Western Pennsylvania:

GENTLEMEN—Another year's experience has been added to the history of our Society, and although it may not be classified as a "red letter" year marked by any remarkable degree of advancement or manifestation of zeal and enthusiasm on the part of its members, it presents some "crumbs of comfort" and points of congratulation when compared with the preceding year, and inspires the hope that the furthest limit of declination has been reached; that we have started on the line of ascendency, and that the Society may continue to go forward in the pathway of usefulness and upward in the line of scientific attainments as the years are added to its history and numbers to its membership.

The attendance, which is a good indicator of the health and vigor of the Society, has shown a marked improvement over that of '86, but is not yet what it should be, nor what it could be, if a little effort was put forth by the members. When we compare the past year's attendance with that of the first four years of our existence as a Society, we are led to ask the question, "What can the matter be?" Is it possible that the efforts of those years have exhausted the vigor, energy and enthusiasm, and paralyzed the ambition of those who did so much to make the organization a success?

The zeal of the older members is inspiring to new ones, and promotes life and activity in the whole. Let it, therefore, be the aim and ambition of every member to stir up the latent fires of enthusiasm, shake off the apparent lassitude, and determine that the coming year shall show such a change for the better that will form a cause of pleasure at the next annual meeting. It will not require any great sacrifice to accomplish all that we could

hope for in that direction. There is a large proportion of our members residents of the two cities, and within easy reach of our rooms, who might attend much more regularly than they do. We respectfully and earnestly urge you to try, and you will be astonished at the success attendant thereon, and in the accomplishment of which you will be instrumental and gratified.

We note with pleasure the change that the committee in charge made at the first of April in our "meeting place," where arrangements have been made to remain until April, 1890. In the care made with these comfortable rooms, away from the noise of the street, and placed on about the same plane of convenience by the elevator as if they were on the ground floor, it should not require very much solicitation to attract the members to visit them frequently (especially every monthly meeting night). The Secretary is always in attendance, to make all callers feel themselves at home by the frankness and suavity of his welcome.

The library, under the care of the committee and the untiring labor of its chairman, has been placed on such a basis that there is no difficulty in procuring the information that its pages contain. It might be remarked in this connection, that all members, and even others, are at perfect liberty to follow the example of the kind donors who contributed its neuclus early in our history as a Society. If any of you have books of the class of which our library is composed that you think would be more beneficial on the shelves of the library, subject to the consultation of all the members, than they are on your library shelves, you need have no hesitancy of making that fact known to the Secretary, who will acknowledge the same and duly credit the donor.

The financial status of the Society is "normal,"—we have not been in debt and do not intend to be. The report of the Treasurer exhibits a satisfactory condition, and new members may not be deterred on account of having to help to pay an old debt by becoming members. With the expenditures at a minimum for the benefits secured, and an economical management of the business of the Society, there is every encouragement towards the enrollment of new members.

The Treasurer has performed a great deal of work for the Society, which has been but a "labor of love" for the welfare

of the Society, and to whom, with the chairman of the Library Committee, the Society is certainly under many obligations. In order to maintain the existing condition of facts relative to our finances, it is absolutely necessary to pay the annual dues promptly and fully. There have been comparatively *few* delinquents. There should *not be any*. And we want to make the record for the coming year, "*all paid up*."

The number of papers presented and read during the year has shown a betterment over last year, thanks to the efforts of the committee who had in charge the "providing of papers." We hope, under the stimulus of the said committee, a further improvement may be realized in the coming year.

The cultivation of "social intercourse" among the members has not been attended to as fully as it should be. Becoming "personally acquainted" is a great aid to the development of the aims of the Society. It is suggested that members come to the rooms *early* on "meeting" nights, and it would be well if a recess could be had during the meeting, or discussion closed fifteen or twenty minutes before the time of adjournment, to afford opportunity in that direction. In the history of the Society there have been some attempts made in the promotion of that object by the participation of a comparative few in two dinners and two summer excursions, one of the latter of which was this past year up the beautiful valley of the Monongahela. The repetition of a short excursion every summer would be a relaxation from business that many need, and would prove enjoyable and profitable.

Our "Standing Committees" seemed to have been impressed with the idea that the prefixed participial adjective "*standing*" expressed the proper quality of the noun "*committee*," which they were in duty bound to accept as a proper qualification of the committee, and as a result they have not moved officially during the whole year. Care should be exercised to acquaint them with the true definition of the word in the vocabulary of the Society, which is to let all else remain standing but the work of the committee.

In conclusion, let each member feel that *this* is *his* Society, in the prosperity of which he is individually interested, and show his zeal by his works, in promoting its success. Let him exercise

energy in preparing a paper on some subject, in taking part in discussion, and assist in evolving from the subject all the information attainable.

There is a diffidence on the part of many intelligent members, which deters them from taking that part in the discussion that their intelligence and information entitle them, and as a consequence the Society is deprived of the benefits that should accrue therefrom. Let that diffidence be overcome; feel at home and add your contributions to the general fund.

For the kindness, favor and courtesy which has been extended by the members to the chair during the year, accept the sincere thanks of the presiding officer, for whatever of seeming merit there has been shown in the exercise of his duties is due to the exemplary manner in which you have made the exercise of governing ability unnecessary.

According to your ability, let your light shine through the papers and discussions of the coming year, reflecting credit on yourselves, honor on the Society, conferring a blessing on the community, and thus affording cause of real pleasure to

Your retiring President,

PITTSBURGH, Jan. 17, 1888. ALEX. DEMPSTER.

After which, the election of officers was ordered. Messrs. Milholland and Grimes were appointed tellers.

They reported thirty-three ballots cast, and the following named persons elected unanimously to serve until January 15th, 1889;

President—Alexander Dempster.
Vice President—two years—W. L. Scaife.
Directors—two years—T. P. Roberts, Chas. Davis.
Secretary—S. M. Wickersham.
Treasurer—A. E. Frost.

After the election, the minutes of the December meeting were read and approved.

A paper, by Thos. J. Bray, was read on

WELDED STEEL TUBES.

This steel is made at the Riverside Steel Works, by Mr. E. L. Wiles, M. E., a graduate of the Stevens Institute of Technology.

For a number of years past experiments have been made with steel as a material for the manufacture of welded pipe, and boiler tubes, but with varying and unsatisfactory results. The writer having made many unsuccessful attempts to substitute steel for iron, and being familiar with the failures of others in that direction, he was therefore ready to raise the stereotyped objections to the use of that metal for welded tubing whenever the subject would be brought to his notice. Early in the spring of 1887, the owners of the Riverside Iron Works, of Wheeling, W. Va., decided to build and operate a tube works for the purpose of utilizing, in the manufacture of iron pipe, the product of their rolling mill and forge plant, which had then laid idle for about three years, by reason of the substitution of steel for iron in the manufacture of nails.

During the progress of the construction of the tube works, the general manager of the company, Mr. Frank J. Hearne, discussed with the writer the possibilities of steel as a material for pipe making, the writer using the following objections to its use:

"It won't do, for I have tried it repeatedly and failed."

"It won't stand the amount of heat required to weld it."

"It cannot be threaded satisfactorily, as it is very destructive to the threading tools."

"It is also entirely too irregular in its character."

These objections did not seem to strike Mr. Hearne as being serious or unsurmountable, for he then stated that he was sure that they could be overcome, and he believed he could furnish a grade of steel skelp that would not have the above faults to any appreciable degree. It was then decided that when the tube works would be in full operation making iron pipe, to put the matter to a practical demonstration.

Towards the latter part of August about thirty tons of steel were made and rolled into skelp and delivered at the tube works as a trial lot, to be made into pipe. It was not necessary to brand or mark this material in any way, for the veriest tyro could distinguish it from iron, either in the strip, skelp or pipe, by its clean, smooth and fine appearance.

The welders at the furnaces said at the outset that it would not do, that it would not stand fire, and by reason of their prejudices

against steel they subjected it to abuse by severe overheating; yet, strange to say, that every piece of that lot made a sound saleable pipe, the welders remarking that "it was the best material to weld they had ever handled." It was threaded and finished with the same success as it was welded. Of course we all thought that this was a "fancy lot" or a "happy hit," the writer reporting that it was just the material for the purpose, and far ahead of iron in every particular.

Soon after this several lots of one hundred tons each were made, and a record kept of the loss in the furnaces, crop ends, leakers, &c., which proved to be so very favorable to the use of steel for pipe making that the company decided to manufacture steel pipe exclusively, and to abandon the use of their forge and iron making plant altogether.

Since the first introduction of Riverside steel tubing thousands of tons have heen made and sold, with great satisfaction to the users thereof, and we are advised by parties in the East that they are using our standard steel pipe for hydraulic purposes at a pressure of one thousand pounds per square inch, with success.

The steel used is made in a Bessemer converter, the chemical analysis I am unable to give correctly at present, but regarding its physical properties, can unhesitatingly say, that it is the smoothest, toughest and kindest material to work with and to weld into pipe that has ever been tried or used by the writer.

The accompanying samples, cut from ordinary Riverside steel pipe, clearly show the character of the material in the cold and hot states. The cold samples were flattened under a steam hammer. The washer was made out of a piece of four inch steel pipe one and one-half inch long, by a blacksmith, by turning one edge of the pipe inwards and flanging out the other edge, then flattening it out into a washer, as shown. The two goblets were made out of two inch and four inch pipe respectively, necked down and welded to form a leg or stem, then flanged out for foot and mouth. This was done to show the amount of punishment the material can stand in a heated condition.

Please notice the butt-weld samples particularly. It is well known that very little pressure is exerted on the edges of the seam in making butt-weld pipe, hence the weld is not a very strong one

usually. There is considerable loss in iron butt-weld pipe by its splitting in the weld on being tested to the regulation pressure of three hundred pounds per square inch. With steel pipe this loss is reduced to less than one per cent. by reason of the superior welding qualities of this steel over iron. I enclose with the samples a few crop ends. These show plainly how little is lost on each end with steel and how well and kindly it welds.

So flattering have been the reports from the users of this pipe that we can unhesitatingly pronounce it a merchantable success.

The following discussion ensued:

Mr. Hunt: The paper certainly shows, as well as do the samples before us, a good record for steel. It is a fact that has been demonstrated by the Riverside people, as well as by many other of the soft steel making concerns, that a steel can be made, low in carbon, high in manganese, and low in sulphur and silicon, especially the latter, which will weld as well as iron. No, I would not say as well, but nearly as well as iron.

There certainly is much steel which is made specially for this purpose which will weld a great deal better than some dry irons. However, it has not been my experience to find in large lots soft steel which would weld as well as the very best grades of iron which were made especially for welding purposes.

Steel for welding should be lower in carbon than .15 per cent.; in manganese it should be high, at least over a half of one per cent., and from that up to one per cent.; in silicon it should be lower than .02 per cent. to get good results, and in sulphur lower than .03 per cent. These are the figures which have beem my experience, and in talking the matter over with many metallurgists I think it is the general experience that these are about the figures which have to be met.

I believe in soft steel for many purposes just as much as this one of tubing, and believe it will come more largely into use. I think there are many cases where iron can be advantageously used, made into large ingots, of say sixteen by eighteen inches, and rolled into bars, for example, like muck bars, fagoted as iron is and forged, and we will have a material which has all the advantages of soft steel, and also the desirable feature that it need

not be cast into the huge ingots which we are now making for steel forgings.

MR. BARNES: I do not know much about steel pipe. I wish I did. I happened to meet Mr. Hearne in town this evening on my way here, and had a very few minutes conversation with him. He spoke of the chemical qualities of this steel and gave me an impression a little different from that which Mr. Hunt has referred to as being that which he would suggest.

The sulphur was about .06 per cent. and the manganese was about .20 to. 25 per cent. I was very decidedly of the impression, from the conversation I had with him, however, that more of their success was due to skill in handling the metal after they got it than to any absolute qualities in the metal itself.

So far as the bending, flattening and flanging is concerned, these are not extraordinary qualities. Quite a number of steel works in Pittsburgh make steel that will do as well as that, and Mr. Hearne himself would admit that if here.

In regard to welding, it is more a question of tact and skill and contrivance on the part of the individual workmen who handles the piece at the moment than anything else, at least that is my impression. I trust those who are more familiar can corroborate this idea.

MR. BOYD: I would like to ask Mr. Hunt if those samples show a perfect weld, and whether steel, being a heavy metal, would not close them up even if not closely welded together?

MR. HUNT: I think in most of these samples, especially the flattened one, if flattened in a way to open up the weld, as it would presumably have been in making the tests, that the tests of the welds are good ones. I have not examined the samples very carefully. I would say undoubtedly the samples might be so treated by bending as to not open the welds—simply flattening down across the weld with the weld in the flat side—it would not have been a severe test of the weld. Here is one right in the flat of the bar. The weld might have been an imperfect one, but had the weld been in the edge of the plate I think that would have been a very good test of it. Indeed, it is very difficult to find where the weld is.

MR. STEWART: I would like to ask if any of these pipes

have been used for gas mains, say eight inch mains, and if they are flexible enough so that they can be adjusted to the uneven surfaces of the gas lines after being laid?

MR. BOYD: I understand Mr. Bray has made no pipe over six inches, but if there is no trouble to make wrought iron pipe to meet these conditions, there should not be any in making steel.

MR. BARNES: In my very brief conversation with Mr. Hearne, he told me that he was making pipe up to eight inches. How large, of course, I do not know, but I see in the audience a gentleman who is thoroughly familiar with the operation of bending pipe. Possibly he could give his impressions in regard to it. I refer to Mr. McCaffrey, and I think his opinion as to how this pipe would bend and stand inequalities of the ground would be well worth taking.

MR ROBERTS: Here is a specimen that Captain Hunt did not probably see. It is a piece of pipe "squashed" down upon itself, probably one and one-half inch in length, I think a four inch pipe. It seems to me that that movement, if done cold, would subject not only the welding point, but all others, to such a peculiarly violent strain that if a pipe will stand that I think it will bend and accommodate itself to curves and grades of streets. I presume that specimen would answer the question.

MR. MCCAFFREY: We had occasion this afternoon to bend a small piece of one and one-half inch pipe, and it bent as nicely as anything we had ever seen. We have never tried any of the larger sizes, yet I should judge they would bend as readily as any of the iron pipe to any shape you would want.

MR. BOYD: I would like to ask Mr. McCaffrey what effect the steel has on tools in cutting threads?

MR. BARNES: I referred to that point with Mr. Hearne to-night myself. These samples you see here are very perfect, indeed, unusually so. Mr. Hearne told me that to cut this class of pipe was a little harder on the taps and dies used; that the metal being so extremely different it would not yield so readily as would the iron pipe, in consequence of which the machinery had to be suited to the work; the wear and tear was slightly greater, and the dies used in cutting the pipe had to be ground a little more frequently than in the case of iron.

But even if this be the case, the thread is undeniably so good as compared with iron pipe that it is well worth any probable difference in cost in the cutting operation itself.

In the absence of Mr. Bray, further discussion was postponed until the next meeting.

On motion, Society adjourned.

S. M. WICKERSHAM,
Secretary.

PITTSBURGH, January 17th, 1888.

Engineers' Society of Western Pennsylvania.

This Society does not hold itself responsible for the opinions of its members.

TUESDAY, February 21st, 1888.

Society met at 8 o'clock, P. M., President Dempster in the chair.

By invitation, the National Electric Light Association, now holding a convention in our city, joined with us in this evening's meeting.

One hundred members and visitors were present.

The minutes of the January 7th meeting were read and approved.

Messrs. Isaac Winn, H. White and E. D. Estrada were elected members.

The subject of the paper for the evening was "Electric Railroads," by Mr. R. McA. Lloyd, the engineer of the electric railroad now in process of construction on the "South Side" of our city. The introduction to the subject was made by Prof. A. E. Frost, Treasurer of the Society, who, in language plain, clear and forcible, explained the technicalities and terms in such a way as to make even a tyro understand their meaning and application. He illustrated his definitions of terms, as a teacher to his class, with as much force and freedom as if he were in the schoolroom and the audience his pupils, whilst they, in return, showed their appreciation by close attention to what he said, and many of them were delighted with the lesson learned.

The reading of the paper by Mr. R. McA. Lloyd followed, viz.:

A Féw Notes on Electric Railways.

An electric railway always consists of three parts:

First. A generating station where the electricity is made.

Second. A number of cars propelled on a track by electric motors.

Third. A medium through which the current is transmitted; which medium may be either metallic conductors—overhead, surface or underground—or storage batteries.

The field covered by each one of these headings has unfolded so many times in the last few years that whereas, three or four years ago, you might have been told in a half hour or so all there was to know about electric railroads, at the present time I can only attempt to bring to your notice, in a desultory way, a few of their most conspicuous features.

Well, the generating station is a good place to start from. We are all familiar with the appearance of a dynamo, and Prof. Frost has just told us the principle of its action, but without going into technicalities I might say another word about the dynamo.

The magnets of a dynamo literally resist every stroke of the engine, every pound of steam pressure behind it, and as no power can ever be lost, energy expended in one way must turn up in some other form. The resistance which the dynamo magnets offer to the engine is converted into an electric current, and the output of the dynamo will be exactly equal to the horse-power expended in driving its armature, minus a small proportion used to excite the field magnets and a smaller proportion lost in friction of bearings and heat.

The ordinary efficiency of a dynamo is 85 or 90 per cent., being far higher than that of a steam engine; the efficiency of the latter rarely rising above 15 per cent.; that is to say, a dynamo loses but 10 per cent. in the conversion of mechanical energy into electrical energy, while a steam engine loses 85 per cent. in converting the energy of heat into mechanical energy.

It is a little ahead of my story, but here let me say that motors, or receivers as we call them in distinction from generators, or dynamos have the same efficiency as the latter. Both are built on

the same general principles, and the sources of waste are the same in each.

The generating consists of a steam plant, engine, boilers, etc., and one or more dynamos, besides a safety cut-out to protect the dynamos from lightning and overloading.

It is not necessary to enumerate the smaller apparatus, but it is important to state that no power station is complete without a smaller space set apart for a repair shop, where a lathe and a handy man with a few tools can save money for the company.

There are two simple methods of distributing electric energy, both of which can be used for electric railways. They are, either by a constant current of varying intensity, or by a varying current of constant intensity. The former is the one used for arc lighting and the latter for incandescent, and is also the easier, safer, and more commonly used for the transmission of power.

Most of us prefer the constant tension method, but there are various opinions as to the best standard of tension, and for my part I should say that a good deal depends on the requirements and circumstances. I recommend (not only as being the system of the company which I represent, but from considerable experience and vivid recollections of personal contact with the subtile fluid) a tension as low as possible. In respect to pressure, electricity is analogous to gas or any fluid. You might sit on the opening of an eight inch low pressure gas main, and thereby stop the flow, but a seat on a two and half inch high pressure pipe would be a difficult one to maintain.

Any E. M. F. or tension above 300 volts is dangerous to human life and becomes troublesome in the matter of leakage. Greater care is necessary all around. I do believe, however, that high tension currents are advisable on a road of considerable length, say in cases where the wires extend more than five miles from the power station. Whatever may be the constant of tension, the dynamos can be built to regulate themselves accurately, and—what is the great beauty of electric transmission of power—produce just as much electricity as the moment demands at the motors on the road. The dynamos respond with a promptness that is simply wonderful to every pull of the motors. But now we must hurry on to the motors. They are running independently of each other

on the road. One, two, or a hundred can all get their current from the same conductors and run in different directions with the same current; and, so long as the capacity of the generating station is not exceeded, will have no influence over each other.

The best place for the motor is under the car and directly supported by the axles which it drives, though some builders with good reason put it on the front platform, which requires a special construction of car and trucks, and an unsymmetrical suspension of the wheels to compensate for the weight of the motor in front. For very heavy service it is often convenient to have the motor in a separate car. If the motor is situated on a car platform the motion of the armature is communicated to the car wheels by sprocket chains or belts.

When the motor is placed under the centre of the car, tooth or worm gearing is used to drive the car axles. It is quite common to equip a street car with two motors, one on each car axle, so that if one motor should be disabled its mate could bring the car home; on the other hand, it is very rarely that a well cared for motor becomes so worthless in one trip that it can't pull itself home; and if such a case should occur, the next car that comes along can push the disabled one ahead of it. Motors can be built for any desired speed and for the development of any desired power. As adapted to tramway service, they are generally arranged so that the speed may be varied by the driver of the car. The weight of motor with gearing and all other apparatus included in the electrical equipment of a tramcar, capable of doing the work of a first class team on any of the Pittsburgh railways, would be 1,500 pounds.

The nominal capacity of such a motor would be seven or eight horse-power, with the ability to work up to fifteen horse-power when necessary, as when starting a heavily loaded car on a seven per cent. gradient.

It has been demonstrated by the use a of dynamometer between the car and whiffletree, that a pair of horses often exerts this enormous strain under like conditions.

The current is generally carried from the generators to the motors by overhead conductors, that being the cheapest method, though there is no reason why underground conductors in conduits

similar to those of cable railways cannot be used with equal satisfaction. As for surface conductors, meaning a third rail insulated from the ground, they are not permissible in any common thoroughfare, and so will not demand our attention this evening.

The overhead conductor may be supported in many ways, either at the side of a street or in the centre, and usually at a height of 20 feet. It consists of one or two hard drawn bare copper wires, stretched more or less tight and suspended in such a way that its supports do not obstruct the passage of a rolling trolley. The trolley may consist of one, two, or more rolling sheaves, combined with a view of traveling easily on the wires without falling off. The car tows its trolley along by a flexible cable, which also carries the current down to the motor.

The thickness of the overhead conductor is based upon the amount of current which it is required to carry, and for the transmission of the same amount of power depends on the electromotive force or tension. Just as a small pipe may transport as much gas or water at a high pressure as a large pipe can at a low pressure, so a small wire can carry as much power at a high tension as a large wire at a low tension. It is, therefore, evident that the high tension presents a saving in first cost of copper wire. The cost of the wire is, however, such a comparatively small item in the equipment of an electric railway, that it is overbalanced by the considerations of safety and insulation; and if we would have a road which could be guaranteed free from danger in case of accidental contact with the current, and at the same time not too wasteful of copper, we must strike a medium which may be worked out from two standpoints. We may either adopt a tension which will be as high as possible without being dangerous, or as low as possible without requiring an enormously large conductor.

In parallel systems of distribution which I have described, it is only necessary to insulate one side of the circuit, just as in water power it is only necessary to save the water in the dam. After the water has gone through the wheel to the pool below, it is useless so far as any influence on the same wheel is concerned.

If one side of an electric circuit is insulated so as to dam it up, as it were, we do not care what becomes of the current when it has gone through the motors to the other side; it is, therefore, quite

common to use the rails for the return to the dynamos—corresponding to the pool below the mill dam.

The current then goes from the insulated conductor through the motor, and by way of the wheels to the rails and back to the dynamos. When a wire is used for the return instead of the rails it serves in the same capacity, and the return current has no power to lose by bad insulation. Where the rails are likely to be continually buried in dust, or other dirt, it is so difficult for the wheels to maintain a metallic contact with them, that the return by an overhead wire is preferable, and there must be either a single trolley on each wire, or a double trolley bearing on the two wires at once, with the wheels on one side insulated from the wheels on the other side, and communicating with the car by a double cable through which the intense current proceeds to the motor and the spent current returns from it.

An electric railway using line conductors is a unit. The generating plant, the conductors and the motors are inseparable. In order to keep the motors running, the conductors must be kept in order, and the dynamos must generate continually; but where storage batteries are used the case is different. I need not describe to you a storage battery, beyond telling you that enough of it to run a street car four hours under ordinary conditions, weighs at least 2,600 pounds, and occupies the space under the seats on both sides of the car. Every car possessed of a motor and storage battery is independent, except when the battery gets short circuited and the stored energy runs out, in which event it has to be hauled home by animal power.

There is, doubtless, a large field of usefulness for storage batteries, and the subject would be interesting to dwell on, but at the present time they are too costly, and not far enough perfect for every day wear and tear on a city street. I do not make this statement from any personal prejudice, but as the opinion of a great many people of wide experience in electric railways. My own company is prepared to equip roads with storage batteries when wanted, but we do not recommend them.

I may say also of storage batteries, that their use entails a further loss of 20 per cent. in the transmission of power from dynamos to motors, and, therefore, necessitates a power plant of

proportionally greater capacity. The batteries, consisting of cells containing lead plates and acidulated water, are charged at the power station, or car shed, by the dynamo current, and fresh sets slipped under the car seats about every four hours. When a more lasting material has been found to take the place of lead in storage batteries we shall look for better results in that quarter. A car supplied with current by an overhead or underground conductor has an unlimited source of power to draw from, but one dependent upon storage batteries may, by a heavy pull, run out of power and have to bear the mortification of a homeward trip with a mule team.

Having briefly touched upon the three elements of an electric railway—the generating station, the motors, and the medium of transmission— I shall now glance at some of the minor features.

Electric brakes are a common and simple institution, and almost anybody can devise a very practicable one; but the old hand brake is after all the most reliable for street car service. There are, however, several ways of controlling an electric car on down grades without the use of brake shoes. On the motors of the St. Clair road, on the South Side, we have provided an arrangement of current switches, by which the heaviest load may be safely and smoothly carried down a hill, the equal of which has never before been attempted by any mechanical tractor. We take a little current from our line wires—about 1½ horse-power from the dynamos to magnetize the motor, or, more accurately speaking, to excite the field magnets; then we allow the motor to act as a generator, converting the force of gravity which pulls it down hill into electricity. Perhaps I have not clearly explained that generators and motors are practically the same in principle, so that a generator may be used as a motor, or a motor as a generator.

Well, the same gearing by which the rotating armature of the motor drives the car up hill, going down hill transmits the motion of the car axles back to the armature, and as the armature revolves about ten times as fast as the car wheels, it is not necessary to run down hill very fast to obtain a high speed for the armature, and as the current generated by the armature is proportional to its speed of rotation in a constant magnetic field, and as the work of driving the armature increases with this current, it stands to reason

that the faster the train runs the greater power resistance it will offer to its own descent.

This amount of current or retarding power can also be increased by diminishing the resistance of the armature circuit, for which purpose we provide a variable resistance to be operated by the driver with a small turning handle.

Cars may descend hills with ease using this device, but I do not consider such methods necessary except on extraordinary grades, and recommend the omission from an electric car of everything that is not absolutely necessary, for complications of wires need much careful watching.

Electric cars should be lit by electric lights, but as for electric bells, electric heaters, electric indicators and fare boxes and other electric fixings, they are nuisances which do well for advertising without adding to the serviceability of a hard working road.

I have been asked a hundred times whether ice and snow interfere with the operation of electric tramways.

Ice and snow interfere with electric tramways just as much as with horse roads. Any track which a horse car can safely go down on, is good enough for an electric car to go down or up on; for if the wheels of the horse car can get enough hold to go down on it without coasting, the wheels of the electric car will take sufficient hold of the same track to climb up it. In short, salt and sand keep an electric road running in winter as well as they do a horse road, with the advantage that there are no horses' feet to be ruined by salt.

The advantages of electricity over horses are many. Speed, perfect control, easy stopping and starting, and economy. I won't bother you with estimates, but from the experience of the roads with which I have been connected, I can assure you that street cars can be run by electricity for less than one-half the expense of horses, and at the same time give the public better service, and in consequence reap a greater reward. Besides this, the ground required by an electric railway plant is small to that of a horse stable, to say nothing of the difference in the character of the employee. Last, I may remind you that electricity never gets the pink eye.

A more formidable rival of electricity is the cable. It is a

good thing, and claims, in common with the former, a great many of the advantages which I have just enumerated, but in cost the cable is away ahead of us.

Electric railways have so far been built too economically, but I am very moderate in statement when I say that an electric tramway can be built in any street in your city for $25,000 per mile, which will give as much satisfaction as the cable at $100,000, and that the cost of operating will be less.

However, as I have neither been invited to run down cables nor run up electricity, I shall not produce all the evidence which would surely convince you that electricity is the ideal power for street railway purposes, and that however ludicrous some of the experimenting has been, it is to-day as reliable as the mule or cable. Of course there are systems on the market which are no credit to the mighty force itself, but there are several companies that after years of discouraging work have brought their hopes to commercial success.

After which Dr. Moses, of New York, said:

The question of electric motors is one that is now so full of interest that I can be prompted to say something about them. I may say something that may be novel, as I have had opportunity of seeing quite recently abroad the development of electric motors there, and of hearing some expressions of opinion as to their probable future for use where other sources of power are now employed.

I was recently in London, and visited a gentleman who is connected with the Metropolitan Underground Railway. He had been looking into the question of motors, as also other stockholders, some of whom had come over to this country for the purpose of studying the matter. The Duke of Sutherland, who is, perhaps, the largest stockholder of the railroad, has given a great deal of personal study, as well as have his engineers, and a contract has been given out recently to Dr. Siemens (Siemens Brothers), of London, for the purpose of putting in a considerable section of electric railway in the Underground Railway of London.

I do not think I could, by any further expression of my own opinion, give you a greater idea of what importance electrical

motors have assumed, than when I tell you that the Metropolitan Underground Railway is one system and the only system of rapid travel in London. There are many omnibus lines, there are some horse car lines, but the only artery for rapid transportation in London is the underground railway.

The disadvantages of steam have become so apparent there that they have made up their minds to abandon it at the first opportunity, which will be the presentation to them of a successful system of electrical transportation.

It is true the conditions there are all favorable. You have an underground road protected from the weather, and no snow or ice which are found so objectionable to horse cars. You have no rain to fill up your conduits; no conductors; you have no teams crossing the road. Short circuit cars of course doubles them up. You have no persons interfering with the line; no small boy down there; and altogether the conditions are very favorable.

Again, on the other hand, the most favorable recommendation to the introduction is the fact that the atmosphere is absolutely intolerable. The foggy condition of London is such that when a puff of smoke gets down there it stays, and there is no way of getting it out, and the result is a most intolerable condition of affairs. I always preferred to go by cab to taking the underground road.

Now they have investigated the system, and I was called upon by Dr. Hopkinson to look into the question for them, and one of the most important systems of electric distribution now in use in America, very successfully, was under consideration by them; they are very willing to give them a trial. I was told by Dr. Siemens himself, that he was perfectly willing to undertake and introduce this American system in place of his own, provided certain arrangements were made.

In regard to the introduction of electric motors in Paris, I will say this, that there is now before the Municipal Council of Paris a proposition on the part of some cable roads, in successful operation in New York and on certain English railways, to put a complete line around Paris between the fortifications and between the tramways, as they are called, but this question, owing to legislative and governmental disturbance, has been cast aside for

the time being. There is, however, under advisement, a system of electrical transportation it is proposed to introduce in France, which has some very interesting features connected with it.

This system has certain very great advantages. I mention them to you as I believe they are novel. The cars are run on high tension, the current in multiple arcs, and they are not interfered with by the potential on the line, because feeders are sent out at certain very short intervals for the purpose of supplying the current, and in that way keep up the potential. It is necessary that the potential should always be uniform, as you know, and although, as has been said, quite a large number of motors can be run on the same line, it is only under certain favorable conditions, because they are like incandescent lamps, strong in multiple arcs along a single line.

There is a fall of potential due to the resistance of the wire. This fall is relatively great, and it has been found necessary to send out feeders. Now it is very necessary that you should avoid this fall of potential, hence the sending out of these feeders. One trouble had to be looked to, however, and that was the small boy. I was told by Mr. Payne, engineer of the Brooklyn bridge, that at first it was impossible to keep the conduits clean, and that they gathered up all sorts of rubbish that could possibly be imagined.

The genius of the inventor has, however, circumvented him, by arranging that when receiving the current the car covers the vulnerable point. I do not know but that there will be found some Achilles heel in it where the small boy will finally get in his work, but as at present devised, it is only when the car covers a certain length of rail that it is possible for the current to operate in the motor.

With this exception, the overhead arrangement is preferable as being safer, though we have still seen the cats and kites of the small boy suspended from the poles.

This is the arrangement proposed to be introduced in Paris. The cable people are confident of their scheme, but so are the electricians.

Society then adjourned for social intercourse with the visitors.

S. M. Wickersham,
Secretary.

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ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

This Society does not hold itself responsible for the opinions of its members.

Society met March 20th, 1888, at 8 o'clock P. M., Vice President J. A. Brashear in the chair.

A. E. Hunt acted as Secretary in the absence of Mr. Wickersham.

Sixty-seven members and four visitors were present.

Geo. Mesta, E. G. Aikman and W. Larimer Jones were elected members.

DISCUSSION OF THE PAPER OF MR. BRAY ON THE WELDING OF STEEL TUBES.

MR. BRAY: The welding of steel tubes is not a new industry by any means, speaking in a general sense. Lap-welded boiler tubes have been made for the past 20 years, but they have always been made out of a very fine grade of material, from selected stock, and at a high price. The common pipe made and put on the market out of Riverside Bessemer steel is a new industry, I believe, and it was one that came upon me rather suddenly.

We built a mill for the purpose of making iron pipe. We are as well prepared to make iron as steel skelp, and have 40 or 42 puddling furnaces now idle and a rolling mill connected with them. During the progress of the work the question of steel pipes was suggested to me by Mr. Hearne, the general manager. I told him I did not think it could be done. I gave him the stereotyped answer usually given, "I have tried it and can't make it." I gave him my reasons. It would be irregular in its character, like all the steel I had treated. It would be of different textures, and if

there was any trouble, the blame was always put on the pipe makers, and that the steel could not be obtained sufficiently regular to manufacture pipe right along without paying a high price for it, and to make common pipe out of that would be ruinous. There would be not only the difficulty of welding, but the difficulty of threading, as the irregularity in the texture would ruin the threading dies. My idea of threading steel was a good deal like cutting screws on rat tail files, that being my experience in other places on bolts and similar articles of steel.

Our general manager said he thought he could overcome all that. I said, "You furnish the material and I will make the pipe." We started in August. The first lot of steel rather surprised me. We made it into pipes, and to my surprise it threaded better than iron, had a better finish, and was brighter. We did not lose a single piece out of that thirty ton lot. I then concluded it was a fancy lot, first rate stuff, but did not think they could keep it up; but they have, and we have been making welded steel pipe at the rate of 100 tons per day. It has been used all over the country. We are shipping all the product of the mill now to-day. We are running full double turn, and we have yet to receive the first complaint from a customer who has used steel pipe. Our customers specify steel pipe when ordering.

There were some questions asked which I will try to answer. I will say at the commencement that I do not know what the composition of steel is. Mr. Hunt has analyzed it, and he will tell you its properties, as I am not a steel maker.

Mr. Barnes says he thinks that a great deal of the success is due to the skill in handling the metal. Mr. Barnes is mistaken. There is no trick or flux or anything about it. We handle it precisely the same as iron. We call it iron, in fact, and weld it as iron, that is, we stick it together just as we do iron. As some people object to the term "welding" used in connection with steel, I will call it sticking, and we stick it so tight that it is stronger at the weld than the original material is.

I will say here, there is no secret, or sleight of hand performance, or trick in the welding. The steel stands more heat than iron, and more abuse than iron in the furnace, and with less waste in welding.

Mr. Boyd asked if the samples shown have a perfect weld, and whether steel, being a heavy metal, would not close up, even if not closely welded together. In order to try that test we put 2,000 lbs. pressure on our pipe and we failed to burst it. It happened to be cold weather, and I prepared six pieces of two inch iron pipe and six pieces of two inch steel pipe, each two feet long, threaded each end and put caps on, with a small screw plug in one end of each to fill them by. They were filled with water and exposed to the cold to freeze. The iron pipe, after three hours exposure, burst and split open. The steel pipes were sound, but the caps over the ends were burst off. I then resorted to welding heads in pieces of iron and steel pipe, with a small screw plug in one end of each. They were filled with water, and the iron pipe burst as before in a few hours after being filled. The steel pipes remained out for forty-eight hours, and were as sound as when put out, but they had been expanded by the force exerted within by water in congealing, and were one-eighth ($\frac{1}{8}$) of an inch larger in diameter than when they were put out. It is said that the expansive force of water in freezing has been estimated at 30,000 lbs. per square inch. (Specimens here shown of the freezing tests.)

If we take iron pipe as a standard I do not think it takes much judgment to see the superiority of steel over iron for pipe.

Mr. Bray here exhibited a large number of samples, showing what he had been able to accomplish with the steel from which he made his pipes.

Some people say if you take steel and heat it to a welding heat a few times it becomes brittle. Here is a piece that has had 27 welding heats. I will ask Mr. Miller is it not as good steel as ever it was?

Mr. Bray here showed samples of polished steel pipe. Most of the samples he exhibited had the work done on them while the material was cold.

The question was asked whether steel pipe will bend. It does, better than iron. That is our experience (here exhibited a sample of coiled steel pipe). I will give you another point about the steel. In making our coupling we suspend them on a rod, and put them in the furnace, not at a welding heat, but at a reasonably high

temperature. Now, if we use a steel rod the steel sticks to them, and therefore we cannot use steel for that purpose. Although it is an iron coupling, yet the steel rod will stick to it, and we have to use iron rods for that purpose.

On the circular distributed are given the ultimate tests of two pieces of iron pipe made by the best concerns in this country, and two pieces of steel pipe made by ourselves. They are shown in the first two numbers in the table 1 and 2, and the last two—11 and 12. You will please notice the reduction of area in both iron and steel.

We find by experience in the matter of welding that the mechanical weld is stronger than the hand weld. We have tried that repeatedly. (Here he exhibited a sample of square pipe made from the steel.)

Another point is the threading. All I can say to you is, that we thread the smaller sizes at a much higher speed than iron. We run about 22 feet per minute up to 1 1-2″ pipe. On the larger sizes we taper down to about 12 or 14 feet per minute. On the 8″ pipe the cut is heavy but the diameter is large. It has a considerable travel and we find that is the better speed. Of course we use the very best material in our dies, a special steel for this work, made by Miller, Metcalf & Parkin, of Pittsburgh, and we also lubricate freely with an abundance of good lard oil flowing over the dies all the time. We have had no trouble in this particular. We have one man to dress up the dies in the lap and one in the buttweld department. They are the same men that did the work when we were making iron pipe, and we have noticed no extra amount of work in cutting the dies. Plumbers do not complain about it. They cut it right along. At first they thought it took a little more power. You can account for that by the reason that the material curls in front of the die holding it back, resisting it, and in iron it crumbles and relieves the die.

We can get a better thread, I believe, on steel than on iron, and on the larger sizes we run a trifle slower. On the smaller sizes, where the work is fine, we run faster. Our percentage of loss by leakers in testing is less than half of one per cent., and steel crop ends are a great deal shorter than iron. It has been used all over the West for all purposes, and we have not had a single complaint.

Now, if I have not covered the ground, or if there is any more light wanted upon the subject, I shall be happy to supply it. The analysis of the material we make the pipe out of will be given you by one who is more familiar than I am with steel making.

MR. BOYD: Do I understand that this is stronger in the weld than in the body of the pipe?

MR. BRAY: If you will step up and look at these pieces, they will speak for themselves. There are two tests here, both of which are stronger at the weld than elsewhere. (See circular.)

MR. BOYD: If you were to take a ring of that pipe and drive a taper plug in it, would it give in the body or the weld?

MR. BRAY: I do not know, sir; I never tried that.

MR. METCALF: Were those rings bent cold?

MR. BRAY: Yes, sir; they were bent cold, but the washer was flattened when hot.

MR. ROBERTS: In that freezing test, was there an actual increase in the diameter of the pipe?

MR. BRAY: Yes, sir. The outside of the pipe was $2\frac{3}{8}''$ diameter. It now measures $2\frac{1}{2}''$.

MR. ROBERTS: I would like to ask where you got the information about the 30,000 lbs.

MR. BRAY: I got that from the books. I do not know it of my own knowledge, but it agrees with the tests shown on circular.

MR. ROBERTS: What was the tensile strain in the circumference of the pipe?

MR. BRAY: I cannot say. We did not think that the pipe would swell. But the result proved that it did.

MR. METCALF: We made a great many thousands of sheets for boiler tubes, and the tubes were used largely by the Pennsylvania Railroad, and others, and people liked them very much, but there was just the objection Mr. Bray mentions, that they had to be made out of the finest material we could get. They were made out of crucible steel and were necessarily expensive. Added to that, the makers of tubes had a monopoly. They were made by only one concern, and they put the price up very close to the price of copper tubes. The difference was so slight, it was hardly an inducement to the railroad companies. Then they found that when the tubes

wore out at the ends they had no means of welding a piece on or repairing them, and when they took them out the scrap was worthless as compared with copper scrap, and this killed the business. For many years there were no steel tubes made in this country, until of late, when they began making them out of much cheaper material.

The only knack required in the material for boiler tubes, as made by the crucible process, was to try to obtain an exact quantity of carbon. What that was I do not know, for we had no chemist connected with us then, and we only had occasional analyses, but I simply know the fact that if we got a little bit too much carbon in the pipes they would not weld, and if there was a little bit too little they would not weld, but I should judge now, from what I have learned since by many determinations of carbon, that the range was about 25 per cent., the rest of the steel being as pure and free from any other impurities as we could make it. The tests that we made were to make the steel stick together. We had to test the steel very carefully before shipping it away, and it was a common thing for our smiths to weld a piece 6 inches long around the horn of the anvil, and then put it under the hammer and crush it down at one blow. It would occasionally open a little, and the weld would part, but when the steel was right it would stand that treatment every time without trouble.

And still, in spite of all that has been said about it, I think there is a distinction between the way iron welds and the way steel welds. I think it is seen very plainly in the two samples Mr. Bray has shown us here to-night, where the iron is torn out in fibers that have been interlaced, but where he has succeeded in separating the steel pipe at all, it shows a smooth surface. There is no interlacing as in iron. I think, seriously, the expression "sticking" steel together is better than welding, for I have never seen soft steel weld in the sense we have seen iron weld. In iron the fibers are interlaced. I have never seen steel part without leaving a smooth surface, just as if it was really stuck together and not interlaced. I think it is a proper distinction to make, and granting all that, I do not think there is any question about the wonderful success Mr. Bray has met with in making steel pipe.

MR. BRAY: It may interest you to know that a gentleman

writes me in regard to steel pipe to the effect that he has been working in that line for two years, and has now a requirement for 40 miles of 36″ water main, and he wants the pipe in lengths of 25 feet if I can get the material large enough.

Mr. Koch (Exhibiting a sample of steel pipe tied in a knot): That was made with the Clapp-Griffith process. In the matter of welding I can remember how we used to weld sheets across the flange, put holes in them, and they are in Atlantic steamers to-day. Also in boilers carrying 150 lbs. of steam.

The great trouble is with the ordinary blacksmith. He thinks he has a big job before him, spits on his hands, works himself up, gets the two together and hits them a terrible blow. This is wrong. You must push it along. We used to weld our plates in the old country. If they came out too short we welded a piece on the end to make them proper length.

I saw Mr. Rowland's process of welding the other day in Brooklyn. He welds with a gas flame and makes a very good job.

In the old country we used to weld propeller shafts that had been made too short, and shafts 22″ in diameter, treated in this manner, are now used on some of the ocean vessels. There is no trouble about welding steel at all, and I quite agree with what Mr. Bray says about it. Take it quietly, and you will have no trouble with it.

We first started to make steel tubes about 1876. We made 4″ tubes for marine boilers. They were made out of ordinary ship steel, and did very well.

In England we can make open hearth steel for plates cheaper than Bessemer. I do not know how it is here. As to Basic steel, it has given great satisfaction, and welds very easily.

(Again exhibiting the sample.) This is a sample of what Clapp-Griffith steel will do. Mr. Bray can do that just as easily. It simply shows you what can be done in the way of steel.

One thing has not yet been mentioned—in relation to the chemical analysis. You will find it is quite true that these samples have been made out of ordinary stock. It is just what I call ordinary Bessemer steel.

Mr. Hunt: I will give the analysis. We have made one, and also one has been made by Mr. Wood, of Carnegie, Phipps & Co., Limited, of the steel which Mr. Bray has shown us.

	Pittsburgh Testing Laboratory.	E. F. Wood.
Carbon,	.05	.05
Manganese,	.38	.36
Phosphorus,	.105	.09
Sulphur,	.059	.074
Silicon,	.03	not taken.

(Mr. Hunt then read the following extract from address of Mr. Adamson, at the May, 1887, meeting of the British Iron and Steel Association, as bearing on the subject.)

Mr. Daniel Adamson, in his presidential address, at the May, 1887, meeting of the British Iron and and Steel Association, said: "Welding steel is now of very great practical importance, and is largely used by makers of steel boilers. In my own works, between 30,000 and 40,000 feet are welded per annum, and, I am pleased to say, with very few failures. The exact composition necessary to secure good welding properties is not yet definitely settled, as the practice of different steel producers varies greatly. But sufficient evidence has now been obtained at my own works to establish the leading fact that the carbon must be low, the manganese four times as much as the carbon, and that the silicon, phosphorus and sulphur combined must not amount to more than one-tenth per cent."

Further on he says: "Personally, I have a considerable number of records of the free welding properties of mild steel, but as the composition varies somewhat in different brands, I prefer, at present, to leave this in the hands of the steel producer."

MR. MILLER: Can you tell us the tensile strength of the steel used in the tubes shown by Mr. Bray?

MR. HUNT: Ordinarily it runs from 55,000 to 60,000 lbs. tensile strength, with an elastic limit of something more than one-half the ultimate; elongation, 25 per cent. in 8″ and reduction of area over 50 per cent.

MR. METCALF: Do those analyses agree with what you gave at the last meeting for welding steel?

MR. HUNT: No, sir, they are higher in both sulphur and phosphorus, but manganese is lower and silicon is about right.

MR. KOCH: We have welded every kind of steel from .02 manganese to 1 1-4 per cent., and from .05 to .60 carbon. You

can weld every kind right along. We do not think anything else makes a particle of difference.

After which D. F. C. Blake read a paper on "The Electrolytic Separation of Gold and Silver," which will be published hereafter.

The following questions were asked and answered, viz.:

DISCUSSION OF THE PAPER OF F. C. BLAKE ON THE ELECTROLYTIC SEPARATION OF GOLD AND SILVER.

MR. KOCH: I would like to ask Mr. Blake a question, whether he has ever obtained electrolytically pure silver wire? I was once sent all over Europe for some of this material, and had great difficulty in obtaining the pure article.

MR. BLAKE: While we have had a great deal of silver, it is almost all shipped to the Mint. We do not usually have any for commercial purposes. We send a little to New York for shipment to Europe for coinage purposes, and probably some may be sold for manufacturing purposes.

A great deal of our silver is 999½ fine. There is sometimes a trace of copper retained in it, also of bismuth and lead, but so small as to be practically nothing. Our silver is much purer than ordinary commercial silver. We can make it so it will be 999⅞ pure to the 1,000 parts.

In response to a question from Mr. Brashear, Mr. Blake responded that if he understood the question aright it was, whether the explosive compound of silver will form when ammonia is present, and whether it will form with potassia present, in the absence of ammonia, and said he could not tell at that moment. That with ammonium he could more readily have an explosive compound with silver than with potassium.

The Society then adjourned.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

This Society does not hold itself responsible for the opinions of its members.

Society met April 17th, 1888, at 8 o'clock P. M., Vice President J. A. Brashear in the chair.

Fifty-six members and four visitors were present.

Minutes of March meeting were read and approved.

Messrs. G. H. Barbour and Louis B. Fulton were elected to membership.

Mr. P. Barnes read the following paper on

THE USE OF ALUMINUM ALLOYS IN THE STEEL MANUFACTURE.

This paper was intended as a note, or *addendum*, to a comprehensive statement by Mr. Koch of the results obtained, in past and present practice, in the use of open-hearth steel furnaces. It cannot be expected, therefore, in the postponement of Mr. Koch's paper, that this note should be in itself either lengthy or conclusive.

The recent special interest in aluminum, as applied to steel making, appears to be largely due to the efforts of energetic men to find a market for the product of their newly devised and partially developed furnaces and processes. The results thus obtained do not clearly appear to be such as to indicate a certainty that important sales will be made in the absence of a selling price which shall be at the same time practicable and safe for the producer and profitable for the consumer. If a maker of such

alloys is able only to say, that "after a new and larger furnace has been put at work," he will be able to sell them at certain rates, it cannot justly be claimed that any basis whatever exists upon which to estimate either the cost or value of the results, which are promised as sure to follow the use of this "material of the future."

Some of the details of quality of steel are reasonably well understood by manufacturers, and the approximate proportions of the elements upon which this quality so largely depends. Careful study has been made, also, of the requirements which must be maintained in steel structures of all sorts and classes, and the relation of the elements in the steel, offered for use in any given case, and the conditions of such use, as depending one upon the other, are substantially agreed upon by all parties concerned. Upon this basis of agreement large technical and commercial dealings are constantly in progress, and into very important fractions of these the new allows do not seem likely to be pressed for use, judging from the assurances of the makers themselves, when the simpler requirements of steel consumers have been explained.

It does not clearly appear, at the present moment, that any new or increased stringency of specification is desired, or proposed, by those who use or arrange for the use of higher qualities of steel, than may be fully and certainly met by a skillful treatment of the common elements which, in all probable cases, must be present in the material. To introduce another element into the combination, and to insure a useful result from its presence, is to lay upon some one a burden of care and study, and of absolute proof, from which the strongest might shrink without discredit, and which, for the present at least, may be left, without hardship or injustice, to the promoters themselves of these useful alloys.

Discussion of the Paper of Mr. Barnes on the Use of Aluminum in Steel.

Mr. Metcalf: Ever since the Society was organized I believe I have had to start all the discusions, whether I knew anything of the subject or not. But I can say one thing, I know as much about aluminum as Mr. Barnes says he does. I am sure of that.

There is one side of this steel discussion, however, that I think Mr. Barnes has ignored altogether. I am perfectly sure that he is just in the position I am; that everything he makes is just right and just what it ought to be; that we do not propose spending any money or time experimenting as long as we can get people to take what we now make. But I think the man who opens the daily mail and gets all the growling letters might possibly see room for improvement in the material furnished. If we could get rid of the seams, the dirt, the laps, the slams and other things of this kind, we would be able to have much pleasanter mails come to us.

The only use I have ever heard of for aluminum in steel is to make it sound—to make the ingot sound. That was the claim made by Oestberg, before the Mining Institute here in Pittsburgh, when he showed those wonderful Mitis metal castings. He said a wonderfully small percentage of aluminum in the steel would quiet it at once. The reasons he gave for it it is not necessary to discuss. They may be right and they may be wrong. I will only say, that we have tried the experiment several times and have noticed that the introduction of a very small quantity of aluminum alloy into the crucible has appeared to have the effect of quieting boiling steel almost immediately, and those gentlemen who are so urgently offering their alloy for use claim that this is the chief purpose of it. We have never carried that out to any great extent, for the reason that our steel is so perfect it does not need it. We tried it just for curiosity. I did take a large lot of it (large for our purpose) for one crucible. There was about 12 per cent. aluminum. We melted it with iron in such proportion that it ought to have contained in the ingot at least five or six per cent. of aluminum, which would be about the same quantity as we found of tungsten in the so-called "self-hardening" steel, to see what the effect would be. The trial resulted in giving us an ingot that we could not hammer or roll, or do anything with. We could not find any heat at which it would work satisfactorily. We finally succeeded in getting a small piece hammered down to a size called bar size, and then tried to turn it into a tool, but without any flattering success; and, so far as our experience with it went, it was the meanest piece of pot metal we ever got hold of.

There was nothing in that experiment to justify us going to any expense in the use of the alloy of aluminum. However, it was our only experiment, and it may have been altogether wrong. The steel may not have contained the aluminum we supposed it did. It may have gone into the slag. We did not follow it up. If there had been any good results obtained from our experiment we might have gone farther.

MR. HUNT: I understand from the vendors of this aluminum alloy, and also from the people at Boston (or near Boston, at the Neponsett Works) where the Mitis steel casting process is being carried out, that one of the principal advantages they claim, at least for the ferro-aluminum in steel and in iron, is the fluidity that it gives to the metal; not only, as has been said, the power of quieting the metal when it is full of gas and in violent ebullition, but it makes the metal, which was sticky at the temperature at which it was before, so fluid that it will pour just as cast iron will, flowing into very thin sections. I have been shown, by one of the agents of the Mitis people, a sample of wrought iron, to which some ferro-aluminum had been added, which had been cast into little threads that looked like a brush, and each one of these threads was as tough almost as soft wrought iron wire and would work as well as a bristle brush; yet it had been cast from ordinary wrought iron, in a crucible to which this ferro-aluminum had been added. I have myself experimented somewhat with it, and I can add to what Mr. Metcalf has already said as to the very remarkable quality of quieting metal that is what we call "wild;" that is, has gas in it and requires settling before it will make a sound ingot. It certainly does make the metal fluid and does make it solid. The price of this alloy is something like $4.00 per pound—for the contained aluminum in the alloy—and it certainly should have very good qualities in order to make the steel makers wish to use it.

I can agree with what Mr. Barnes has already said, that with the present requirements for soft steel, in the specifications for structural material at least, there will probably be no demand in the near future for such an extra quality as would require $4.00 per pound material to be added to it to make it better. In other words, that soft steel is now being made which does answer all

the requirements of the ordinary specifications without any $4.00 per pound material being added to it.

MR. SCAIFE: I should like to ask Mr. Hunt if he has analyzed any specimens of the so-called silicon-aluminum alloy made in Massachusetts, and if so, what he found in them?

MR. HUNT: Do you mean those specimens at Boston? If so, I think I gave the analysis here some time since. They contained enough phosphorus to make friction matches, enough sulphur to make the matches burn well, and the iron was enough to make it heavy, it containing about 95 per cent. metallic iron. The silicon was considerable, as much as would be in ordinary pig iron of cheap quality, but for aluminum, I did not find any.

MR. HIBBARD: I did not come here prepared to say anything, but I think there is a little to be said on the other side about this use of aluminum in steel. We tried it, I think, three times. The first two were, for various reasons, unsuccessful, but the third time it turned out very well. I think we made a heat of the steel about .18 carbon and .41 manganese and 1-10 per cent. of aluminum in it, and it tested remarkably well. The stock was very ordinary, about one-tenth of one per cent. phosphorus, and, I suppose, half as much sulphur. The average tensile strength of that rolled into half inch plates was about 70,000 lbs., and the elongation, I think, about 26½ per cent. That was the average of four test pieces. We thought that was very good metal for ordinary stock.

MR. HUNT: What would it have done without the aluminum?

MR. HIBBARD: I don't know exactly, but should say that without the aluminum we would have had perhaps 65,000 lbs. tensile, with probably 22 or 23 per cent. elongation. Probably the effect of the aluminum added to the steel was to make a difference of 5,000 lbs. in tensile and 3 in elongation.

By a MEMBER: I would like to ask Mr. Hibbard if they obtained from a section of the ingot the specific gravity of the metal. There might be a great difference in the analysis of the outside and of the inside of the ingot.

MR. HIBBARD: There was no analyses made of the different parts. The only examination made was to break an ingot in two and look at it; it was absolutely solid. The metal, some of

which was put into forgings, turned up very well. The chips came off regularly and smoothly. It was excellent steel.

MR. BRASHEAR: I think, perhaps, that there is something in the making of alloys, especially in reference to the aluminum and kindred alloys, in having the alloy made with some reference to the mixture according to their molecular weights. This factor in the mixture of metals is in a great measure overlooked.

I have had some experience with aluminum alloys. I visited Col. Frishmuth, of Philadelphia, who is making probably the greatest amount of aluminum and the largest bars made in the United States. I was introduced to him by Prof. George F. Barker, of the University of Pennsylvania, and I found him quite a genial old gentleman, though very chary about telling his so-called secrets, for he makes the aluminum entirely free from the sodium process, and that is why he claims to have cheapened it. I bought quite a quantity of it from him, intending to make some experiments in alloys for the manufacture of diffraction gratings. We have found that in the manufacture of metal for diffraction gratings we get the most perfect metal, the most beautiful surfaces, by making use of metals closely allied to the molecular weights, so that there will be a chemical affinity as well as a mechanical mixture. In this way we found that we got a metal infinitely superior to those metals that are made without reference to their molecular weights. We made some experiments in the aluminum bronze, and other alloys of aluminum, and got some very good results.

A claim has been set up by a company in London that they have made aluminum bars that did not oxidize even after exposure to the atmosphere of London (which is pretty rank, you know) for six months. But I take this statement *cum grano salis*, because I do not believe such a metal exists, for oxygen will attack anything if you give it time enough. A German chemist had a lot of spoons, knives and forks made from aluminum, and at the same time used some silver spoons, knives and forks. He had been under the impression that the aluminum was a non-oxidizing metal, but at the end of a year (after the utensils had had about the same use) he found that the aluminum had wasted more than the silver—had oxidized more than the silver, so that we cannot depend upon it as a perfectly non-oxidizing metal.

I cannot speak of its use as an alloy in steel, but I know it makes a magnificent alloy if partly mixed with copper, tin and other metals.

MR. CLAPP: I would like to say something about oxidation of aluminum in regard to a small balance pan we had in constant use in our laboratory for three years. It weighed originally 1.85 grammes. At the end of over two years constant use, weighing iron and steel drillings, it had lost three milligrammes. The pan was exposed to the sliding action of the drillings, and at the same time to the fumes necessarily arising in a laboratory.

MR. ROBERTS: If metal is perfectly polished will it rust as quickly as when not so polished?

MR. BRASHEAR: We have had some very curious experiments in regard to that. The speculum metal from which we make our diffraction gratings we find can be polished to a point which we call a blach polish, where it resists oxidation for almost an indefinite time. We have an instance of this in some of the speculum metal mirrors which were polished by Short, a telescope maker of London, and they are almost as brilliant to-day as when they left the works. Some of them are one hundred and twenty years old.

MR. HIBBARD (in reply to Mr. Barnes): In the case I have mentioned, the silicon could not account for the phenomena. The alloy contained about 9 per cent. of aluminum and about 3 per cent. of silicon, which would add about .03 per cent. of silicon, and this would not be enough. The steel casting maker would not feel satisfied to put that amount in hoping to get a sound casting. They put in, I think, about eight times that much, say from .25 to .30 per cent. silicon.

Society adjourned at 9.30 P. M.

S. M. WICKERSHAM,
Secretary.

Engineers' Society of Western Pennsylvania.

This Society does not hold itself responsible for the opinions of its members.

Pittsburgh, May 16th, 1888.

Society met at rooms at eight o'clock, p. m., President Alex. Dempster in the chair.

Vice Presidents J. A. Brashear and W. L. Scaife, Directors Hunt and Taylor, and forty-six members, were present.

The minutes of April meeting were read and approved.

G. W. Ketteridge, Engineer Maintenance of Way, was elected to membership.

The following paper was then read:

Fifteen Years' Experience in Open Hearth Steel.

BY WALTER E. KOCH, M. A. (CANTAB.)

One of the first open hearth furnaces was, I believe, built at Crewe in 1868; about the same time that Martin perfected the Scrap process. Before this time, however, the late Sir William Siemens had built and worked successfully a small one ton open hearth furnace, which stood in a back yard in Hampton street, Birmingham. In 1869, curiously enough, basic bottoms were recommended by M. LeChatelier, a great French metallurgist, and bottoms of lime and dolomite were tried, but after a while sand was found to stand the best, and it was far easier to repair; now the basic bottom is coming to the front again. In 1869, Landore,

and the Steel Co. of Scotland, were started, and furnaces were also built at Dowlais and Panteg. In the next year or so every conceivable form of furnace was tried, the regenerators were put on the top, sides and bottom, and the rest of the furnace underwent a multitude of changes. The only form we did not try was the circular furnace built into a shell of iron, as in the Lash type, and this is a step in advance. The bricks gave a good deal of trouble and so did the roofs, and I am sorry to say the metal would break out or the roof tumble in occasionally and make a good deal of trouble. Now we can make 500 or 600 heats without repairs instead of 50 or 60, or sometimes only 5 or 6. Evolving a new process is not an easy task. In 1872, bauxite, a mineral consisting of 54 per cent. aluminum, 42 per cent. oxide iron, and 4 per cent. silica, was suggested, but that also has died out; it was not an easy bottom to mend and was very costly.

Materials also were different to what we have now. 20 per cent. manganese was a high product, and when we got up to 50 per cent. ferro, we thought we were doing wonders. Owing to the low and irregular manganese products we got very irregular results in the carbon in the steel, and we had to watch matters very closely. We thought .20 carbon very soft steel at first, and it was really far more difficult to make .20 carbon steel then, than to make .10 carbon steel now.

Two steel open hearth processes were in use, the Siemens-Martin or Scrap process, and the Siemens Ore process. In the first case you take enough pig iron to form a bath, and then decarburize with scrap. In those days we suffered from holes in the bottom, and we used to keep punchings and turnings handy to throw in the holes and save a mess.

Then Sir Wm. Siemens and Mr. Arthur Willis worked out the Ore process, which is now in use in all the British and some American steel works, and consists in decarburizing a bath of pig iron, alone, or mixed with some scrap, by means of a pure iron ore; this is nothing more nor less than a puddling process at a high temperature. The only trouble in using pig and ore alone (without any scrap at all) is that you got such a thick covering of slag over the metal, that the metal was liable to get pasty, and it was very hard on the roof and sides of the furnace. We tried

tapping off the cinder, but this did not work very well, and finally we settled down to charges of pig iron with about one-third to one-half scrap, and when it was all melted we boiled it with ore till it was down to pitch. From that time on the open hearth process has been a decided success. This brings us down to the year 1873.

About the same time we found out that silicon was a good thing to keep the metal quiet in the moulds, and for this purpose we used a pig iron containing—

Carbon, 3 per cent.,
Sulphur, .03,
Phosphorus, .30,
Manganese, .30,
Silicon, 8.50 per cent. to 10 per cent.

This was added to the bath with the spiegel and ferro-manganese, and sometimes it quieted the metal and sometimes it did not, and to this day I would rather depend on good furnace work than on silicon.

After this we were inundated with patents and cranks, and worried to use nitre, litharge, chalk, flour, soda, clay, salt, sand, magnesia, lime, etc., to be put in the furnace or in the ladle. The nitre experiment was rather more successful than most of them, as it distributed the steel liberally around and put a hole through the roof. After a while the quacks left us alone.

One of our earliest performances was to convert iron rails into steel rails; the sections used were flange, double heads and bridge, and contained about 3-10 per cent. phosphorus. We took 3 tons of hæmatite pig and 4½ tons iron rails and melted them down, using about 700 lbs. motka ore to each heat to bring the metal to pitch. We then added ½ per cent. of silicon pig and from 2 to 3 per cent. of 50 per cent. ferro-manganese. The result was an excellent rail. I give a few analysis of these high phosphorus rails:

Carbon,	.26	.28	.23	.22	.22	.25	.22	.20
Silicon,	.102	.10	.09	.10	.10	.09	.10	.10
Sulphur,	.12	.104	.07	.064	.10	.08	.02	.16
Phosphorus,	.203	.252	.244	.179	.233	.205	.133	.181
Manganese,	.576	.792	.602	.957	.540	.756	1.26	.540

Some rails reported as exceptionally good analysed as below :

Carbon,	.23	.24	.25	.30	.21
Silicon,	.03	.03	.018	.075	.06
Sulphur,	.104	.120	.088	.109	.124
Phosphorus,	.234	.287	.255	.223	.272
Manganese,	.792	1.234	.900	1.008	.810
Copper,	——	——	.014	.02	——

These rails were laid down on one of the largest and hardest worked roads in England, after going through the usual falling weight test, and stood well. This business ended with the exhaustion of the supply of iron rails from the West of England.

The next thing we had was a copper excitement, and we had to analyse every rail heat for copper, and we certainly found from .01 to .07 Cu. in the rails, but we never could find it affected the rails in the slightest degree, and so the scare died out.

Even before 1876 we had rolled some large sections of flange rails at Landore; one rail stood 4½ in. high, with ¾ in. web, and a flange 6¼ in. wide. They weighed about 96 lbs. to the yard, and were rolled in the usual 30 ft. length. Our rails used to run then from .28 to .48 carbon, phosphorus .04 to .06, sulphur .02 to .06, manganese .5 to .8. We made large quantities of rails by the O. H. process in those days, but now we cannot compete with the Bessemer in this branch of steel manufacture.

We made lots of axles both for cars and locomotives. They were hammered down from 15 in. square ingots under a 7-ton hammer into 7 in. and 8 in. blooms, cornered, reheated and finished. The analysis would run as under :

Carbon,	*.22 to .35,
Phosphorus,	.04 to .06,
Sulphur,	.02 to .05,
Manganese,	.50 to .70,

* Such axles should bend double cold.

	8 in. Elongation.
The soft axles ran about 70-75,000 lbs. ultimate,	25 per cent.
" hard " " " 80-90,000 " "	20 per cent.

They were tested under a falling weight varying from 1000 lbs. to 1 ton, and falling 5 to 35 feet, the axle being put on 3 to 3½

feet centres and turned after each blow. Statistics show in Great Britain that 8 iron axles break for every 1 of steel, and it is astonishing to me that so many iron axles are still in use in this progressive country. The last iron axle I saw forged in England was in 1878, in 1888 I still see them being made in Pittsburgh's leading forges. I have seen plenty of broken axles in this country, and nearly every one I can remember was from defective welding; surely steel must be better. The tendency here is to use a softer axle material, say about .10 to .12 carbon, with under .10 phosphorus, and manganese .50 to .60, and this should give an excellent material far surpassing any iron.

We were also early in the field in the manufacture of tires. These we rolled from 18 in. up to 8 feet diameter. They were made at first by cutting up large square ingots into blocks, and then punching a hole through them; later on the blocks were cast directly from the furnace in many shapes; having next formed them into big heavy rings, they were finally rolled out on a vertical or horizontal mill. Our mill at Landore was a Webb horizontal tire mill, with hydraulic attachments to form and shape the tire as it was spun around.

We made three kinds—

Soft,	.22 to .28	Carbon	Sulphur,	.05
Medium,	.35 to .45	"	Phosphorus,	.05
Hard,	.50 to .60	"	Manganese,	.72

I notice that here you use a softer axle but a harder tire. I think .60 carbon is too high for tires, for I remember seeing six broken in succession under the drop one bright frosty morning in 1878.

We also made on the same mill weldless rings and angles for boilers. Some of the English railroads built their locomotive boilers of plates butted together, and used these rings in the joints; they were made in the same way as tires, but of soft boiler steel. The weldless angle rings were used to connect the boiler to the smoke-box and fire-box. A very strong boiler was built up in this way, as the rings strengthen the boiler very much.

We also made rings for lips or scrapers for dredgers; by turning them around they lasted a long time. Of course they were of hard, tough steel.

steel for marine work, and if made right, it is the safest and cheapest material.

This brings me to talk of castings. In 1877 we were doing a good deal in that line at Landore; we made anchors—

Carbon, .58	Silicon, .186
Phosphorus and Sulphur, .06	Manganese, .65.

We also made rolls, .25 to .55 carbon, manganese .60 to .90, but except for small rolls for tin-plates they were not very successful; now plenty of large steel rolls are made. We also made steel shells with .70 carbon.

I have here an analysis of a cast steel shaft made for the British navy in 1879: .16 carbon, .03 silicon, .05 phosphorus and sulphur, .882 manganese. The test gave 54,650 lbs. ultimate and 20 per cent. elongation in 8 inches. There was no silicon-manganese or ferro-silicon used, and it turned up as smooth and solid as possible; there was no pipe. A piece slotted out twisted five times round itself before fracture. It is now running in one of the large ironclads. I have seen such excellent castings made in Pittsburgh that except as history there is no need to dilate on this subject.

I now come to the last and most interesting part of my story, *i.e.* the manufacture of steel plates; and here I may proudly say that the open hearth process is now without a peer as an efficient producer of these necessary articles, although there are some of us who can remember the time when it was far otherwise.

From the earliest days of the open hearth, the manufacture of plates was sought after. Some of the first plates were used in boilers, then in ships, etc. Locomotive frame plates were among the first uses of O. H. steel. Here the frames of locomotives are built up, but across the water solid frame plates from 18 in. to 24 in. wide, and as long as the locomotive, are used, and this carries everything and gives great rigidity. They are rolled on plate mills and sheared, as universal mills are not popular in England, owing to the expense in repairs.

In England there are several standards for plates, The Government, Lloyds and "Liverpool" Lloyds, Bureau Veritas and Board of Trade.

A standard ship plate such as would suit the government or Lloyds usually contains about .17 carbon, .04 silicon, .06 phosphorus, .06 sulphur, and from .70 to .80 manganese. An average of 40 tests I have here recorded gave 63,700 lbs. ultimate, with 26 to 28 per cent. elongation in 8 in.

"Liverpool" Lloyds require a harder steel; their analysis would be .19 to .21 carbon, and manganese .80. The ultimate would be 71,000 to 72,000, with 28 per cent. elongation in 8 in. The elongation seems to rise with the manganese. I find test pieces with .60 manganese give about 2 per cent. less elongation than those with .90 manganese.

We used to cast ingots 15 to 18 in. thick and even thicker, and then hammer them down into slabs, which were cut to the required weight and then reheated and finished in a two-high reversing mill. Now a blooming mill is used in many mills for slabbing, and it seems to make a softer plate than that made by hammering.

We made some pretty hard bridge plates in 1879; they were .40 carbon. The tests showed 96,000 lbs. ultimate, with 18 per cent. elongation in 8 in. They were too hard and gave trouble. A good deal of bridge steel was made .35 carbon, and gave 82,000 lbs. ultimate, with 18 per cent. elongation in 8 in. I think myself that bridge steel should run about 62,000 lbs. ultimate, with 20 per cent. elongation in 8 in., and I find engineers are arriving at the same conclusion. They then have steel at about its best point as regards strength and ductility combined.

Some of the first plates made were boiler plates, but they were too high in carbon, and it was some little time before we got down to the fine material we have now; cracking after punching, flanging or scarfing was not unknown by any means then. The Board of Trade in England have a very severe test for boiler steel; they require, or did require, 25 per cent. elongation in 10 in. instead of 8 in., and 60,000 lbs. ultimate. I used to make the steel .15 to .16 carbon, keep the phosphorus and sulphur very low (under .04), and the manganese about .75; this gave very good results. 70 tests gave an average of 63,350 lbs. ultimate, and over 27 per cent. elongation in 10 in.; some gave as high as

64,000 lbs. and 28.5 per cent. Good boiler plate for marine boilers made in Glasgow in 1880 gave the following results:

¾ plate.	Board of Trade test.	
lbs.	Elongation.	
Ultimate, 61,000	33.75 in 10 in.	
62,000	32.20 "	Reduction of area,
63,000	33.75 "	52 per cent.
64.500	31.80 "	

Analysis—Carbon .15, Phosphorus .04, Sulphur .05, Manganese .72.

While I am on the subject of boiler steel, I would say that it is very important to keep the phosphorus low, especially in locomotive fire-boxes, where the expansion and contraction is very great. I think that any plate which has water on one side and fire on the other should be very soft, ductile and low in phosphorus and sulphur, especially phosphorus.

Ten years ago we used up our plate ends for skelp for boiler tubes (for mild steel welds very easily); I have looked up analysis of the various steels I have welded in large quantities, for I must tell you that in Scotland we used to weld plates together to form the fronts of boilers, and after welding we flanged them and cut out the door holes, etc.; there are plenty of such boilers in use, carrying heavy steam pressures and doing their work well.

WELDING STEELS.

CARBON.	SILICON.	PHOSPHORUS.	SULPHUR.	MANGANESE.	
15	tr.	.04	.02	.216	
14	tr.	.07	.05	.25	
14	tr.	.04	.05	.36	
18	.03	.04	.02	.58	
15	.03	.03	.05	.29	
17	.02	.04	.02	.38	
14	.03	.06	.04	.72	
16	.01	.06	.03	.828	
12		.07	.12	.34	Not very weldable.
15	.03	.05	.05	.80	Boiler front steel.
14		.06	.07	.60	

These were welded in an ordinary coke fire with blast by a dozen different smiths.

I once had a steel with .152 sulphur, which would not weld at all; the other constituents were normal. Carbon does not affect

the welding properties, as I have welded steel from. 05 to .08 carbon. Phosphorus may do when over .08. Sulphur seems to affect it most, and manganese not at all, at least up to 1 per cent. Over that I have never tried. I think people fail in welding steel because they hit at it instead of pushing it together. Steel does not require brutal treatment in any department, that is why hydraulic machinery is becoming so general. Steel requires pushing into place, not hammering brutally; cracking in boiler shops is generally caused by unnecessary flogging, making hard knots of condensed metal, which of course behave differently on cooling to the surrounding unhurt material, and so cracking takes place. Again, steel must be worked red-hot or quite cold, and certainly should not be punished at a blue heat. I remember in the early days certain shops cracked plates frequently while others never had a cracked plate, although they came from the same heat, and often maybe from the same ingot.

I have here a test to illustrate this point. A .17 carbon plate giving 61,200 lbs. and 21 per cent. in 8 in., was flogged in the good old style and then tested again, when it gave 75,200 lbs. and only 14 per cent. in 8 in., a loss of 33 per cent. in ductility; and I could multiply such examples, but "ex uno disce omnes."

Here are some interesting tests made by the British Government some ten years ago:

Plate before quenching,	62,720 lbs.	and	25	per cent.	in 8. in.
" after "	84,500 "	"	20	"	" 8. in.
" then annealed,	62,720 "	"	25	"	" 8. in.

The carbon was .16 and manganese .54.

This plate was ½ in. thick; when bent at a blue heat it cracked at 90°, but punched cold and sheared it bent double, cold, right through the punched hole, without a sign of a crack. Any good steel will do this.

Ordinary plates, rolled,	68,000	and	23.4	in	8 in.
" " annealed,	62,000	"	27.5	"	8 "
" " as rolled,	59,350	"	25.6	"	8 "
" " quenched,	71,700	"	17.5	"	8 "
" " as rolled,	67,000	"	25.5	"	8 "
" " quenched,	82,700	"	20	"	8 "

¾ plate gave 65,700 and 21 per cent. in 8 in.; reheated and rolled down to ⅜ it gave 70,200 and 19 per cent. in 8 in.

In the matter of Government tests, some people think those of the U. S. navy department rather stiff. I dare say they are; but they do not require better steel than any of the twelve different governments for whom I made steel long before I made it for the U. S. navy.

I find the average of such plates was 64,300 lbs., with 26 per cent. in 8 in., some giving 63,600 lbs., with 26.4 in 8 in., and so on. Now, our tests here show, as far as we have gone with U. S. navy steel, about 62,720 lbs., with 27 per cent. in 8 in., and reduction, 53 per cent. So, you sée, we are making about the same steel as for the other governments. In our own mill, at Spang's, I am making just about the same class of steel as we made years ago at Landore for the "Iris" and "Mercury."

Now, I wish to point out a difference between British and American plates. I noticed that to get the same results we have to use a different steel, at least different chemically. I find that .16 carbon and .80 manganese gives 64,000 lbs. and 26 per cent. in 8 in. in Great Britain, whereas to get that here in the same thickness of plate (⅜ in.) requires .19 to .21 carbon, the manganese standing about .50; the phosphorus being under .05 in both cases. Now, I wanted to find out more about this, so I sent across to one of the largest steel works, where they turn out 1,000 tons of plates a week, to get their average analysis for government plates; it is, .16 to .17 carbon; phosphorus and sulphur each under .05; silicon, .01; copper, .05; manganese, .50 to .60; average test, 65,000 lbs. and 25 per cent. in 8 in. The plates I made in Glasgow in 1879 and 1880 were .16 carbon and .80 manganese, and I got an average tensile of 65,000 lbs., with 26 per cent. in 8 in. To make the same plates here, with the same materials, I have to use at least three points higher carbon, and I attribute this to our system here of rolling direct from the ingot in a three-high mill. Hammering, or blooming and reheating, certainly makes a tougher, harder steel than direct rolling; it also does another thing; it equalizes the steel, for I find that the variations in carbon do not affect the steel so much as they do here.

We can make a greater variety of steel by our method of rolling than they can on the other side. I think to be able to make steel plates from 48,000 lbs. up is a great triumph. Foreign makers beat their steel together, so to speak, whereas we draw ours more; hence, I maintain that here in Pittsburgh we are making some of the finest steel plates possible, and in such variety that we can please the man who hankers after the very softest steel. I did not find it easy in England to make steel below 55,000 lbs.; here we can make it right down to 50,000 lbs., and hence I believe we get a better steel for fire-boxes and have fewer failures than on the other side. Steel plates below 60,000 lbs. are not such common articles in Britain as here, unless things have altered lately. In conclusion I may say that I think the three-high mill is far the best system for the manufacture of plates, especially where a soft and highly ductile plate is required, and I think that we Pittsburghers have done well in this direction, and can do better yet.

Let me add that this paper is entirely compiled from my own diaries and notes, and that no publication whatever has been consulted.

Since the above was written I have received the following notes from a friend of mine in England concerning O. H. steel: He says, "Puddling furnaces are being torn down everywhere to make room for open-hearths. I myself am engaged in putting down five twenty-ton O. H. furnaces to replace the puddling furnaces of a large iron mill." A friend of mine is doing the same thing in the Midland district. The *Pall Mall* states that in Glasgow last year the consumption of steel for boilers, ships, bridges, etc., was over 500,000 tons, while less than 20,000 tons of iron were used; ten years ago the boot was on the other leg; and this is in the face of puddling at $1.75 a ton. A writer in the *Contemporary Review* states that over 40,000 iron workers have been displaced already by the change from iron to steel, and twenty-five millions of dollars worth of iron plant has been sacrificed. At the end of 1887 works were in course of erection in Great Britain equal to an additional production of 5,400 tons a week of O. H. steel, and the total production last year of O. H.

steel was not far off 1,000,000 tons. 25 per cent. less iron was made in 1887 than in 1884. These figures are suggestive, and I think we are moving in the same direction.

MR. H. D. HIBBARD: We made some tests some time ago in connection with quenching and annealing—two from one heat and one from another. We tested pieces chilled and annealed, and also of the plates just as rolled. The chilled and annealed pieces were heated to redness, plunged into water till cold, heated again to redness and allowed to cool. In one piece of each heat so treated the elongation rose from 27 per cent. to 32 per cent. in 8 in. The second test of the first heat, however, remained about the same in elongation. In all the tensile strength dropped two or three thousand pounds per square inch.

Plain annealing pieces from the same plates showed somewhat higher elongation and lower tensile strength.

The two first tests point to the desirability of chilling and annealing. The second test may not have been fairly used.

MR. HUNT: I have been very much interested in the paper which has been delivered, and if I took the language correctly I understood Mr. Koch to say that the steel the English make has carbon .16, manganese 8-10 per cent., and they get on an average, from 3-8 plate a tensile strength of 65,000 lbs. and an elongation of 25 per cent.; that with the steel made in this country, averageing carbon .19 to .21, manganese 5-10 per cent., we get only 62,000 lbs. tensile with 27 per cent. elongation. Now to summarize this would mean that the steel made in this country was higher in carbon by from 3 to 5 hundreds, and in manganese at least 3-10 per cent. lower than in England, and yet with the higher carbon it is softer in tensile strength by at least 3,000 lbs. per square inch.

Now it seems to me that there are several reasons for this. In the first place, the finish that the material gets, the heat at which the plates are rolled, will affect the tensile strength, and it would be to suppose that the heat at which the English plate is finished in rolling is colder than in this country.

The second point that comes to my mind is that Mr. Koch has

explained it himself in that they hammer their slabs, while we roll direct from the ingot to the steel plate. It has been my experience, as well as that of Mr. Koch, and that of others will bear me out, that steel which has been hammered is a harder steel in its results than steel which, of the same character, is rolled direct, even though the temperature at which it is rolled is the same, or the chemical results the same. Hammering certainly does give a harder steel.

Also I was much interested in what Mr. Koch said of the quenching test. I suppose the manganese in the steel of which he quotes was added by the English system, and the manganese added after the metal was tapped from the furnace as it is going through the spout. It is a common practice in England to add the ferro-manganese after the metal has been tapped in a finely powdered state as it goes into the ladle. In this way there is less wastage. If this had been done in all cases there would have been a much greater reduction in the percentage of manganese in the finished steel. When the manganese is put into the bath considerable gets into the slag. We expect to obtain manganese .50, instead of .80, as quoted in the results, if the manganese was added in English style.

My experience with the quenching and bending tests is the same as what were quoted. You take steel, no matter how low it is in carbon, it will harden, harden in the sense of giving higher results in tensile strength. By heating to a red heat and quenching in water it will give higher results in tension; steel, if plunged in brine, will give higher results than when plunged in water, and if quenched in oil will give results midway between brine and water. This hardening can be relieved if the steel is afterwards annealed. Perhaps this may be one of the causes of failures in marine boilers. Portions of the plate of the fire-box which have been subjected to a high heat may be subject to a sudden quenching, as in the case of the vessel shipping a sea, or taking water, so as to suddenly cool the fire-box plates. It is a fact that no matter how low the carbon you do get these results of hardening in steel, much more so than in iron, although I have found that with the best soft iron—Swedish iron—you will

get higher tensile strength results if it is heated red-hot and subjected to water cooling before being pulled in the testing machine.

Mr. BRASHEAR then exhibited some samples of aluminum alloy, which was said to contain 98 per cent. pure metal.

Mr. METCALF gave briefly the process of manufacture at Findlay, Ohio, as it was described to him by one of its representatives —but that its cost put it out of reach of the manufacturers at present, being $4 per lb.

Society then adjourned.

S. M. WICKERSHAM,
Secretary.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

This Society does not hold itself responsible for the opinions of its members.

PITTSBURGH, June 19th, 1888.

Society met at the rooms at eight o'clock P. M.

President Dempster in the chair.

Vice Presidents Brashear and Scaife, and T. P. Roberts, A. E. Hunt, of the Board of Directors, and twenty members, being present.

B. Speer, R. B. Lean, C. H. Davis, A. C. Cunningham, E. H. Kenyon, A. F. Keating, Frank J. Kimball, Wm. Bakewell, and A. L. Reineman, were elected members.

DISCUSSION OF W. E. KOCH'S PAPER ON OPEN HEARTH STEEL.

MR. C. E. STAFFORD: There are some points in regard to which I would like to ask Mr. Koch to give us a little more information. He speaks here of the fact that the English steels have very much more elongation than ours—the steels which are commonly used in this country. I would like to know to what he ascribes that difference in physical testing. It is no doubt due to difference in practice, but to just what part of the practice is that difference due?

MR. KOCH: It seems to me the difference really is the way of rolling. If you will recollect the way plates are rolled here, and the way plates are rolled in England, I think you will understand the difference. Our method of rolling plates here is

very simple and very good—I think the best. We take steel, and we roll it directly from the ingot. If we wish to make a wide plate, we spread it, and draw it in all directions. The result is, we get the steel in a very good condition and make an excellent plate. In England it is different. There we make our ingots very large. We make ingots up to 8 or 10 tons weight. Then we roll them into slabs. Then we handle the slab in such a way that when it comes into the finishing mill the length of the slab becomes the width of the plate. Then when it comes to the finishing rolls it is rolled that way, continuously backward and forward. There is no spreading, as here; it is simply rolled backward and forward. The result is, you get a very great pull in one direction. If you take a cross test and a length test in plates, you will find there is considerable difference between the cross and length tests. People say to me sometimes, "Your test for the British government plates is very easy. It is only 20 per cent. in eight inches." Twenty per cent. in a lengthwise test is very easy, but when you come to pull crosswise I have seen them break down. I think if you will consider the two ways in which plates are made, you will see at once that our method is the better one. One of the leading manufacturers in the old country wrote, asking me to give him the result of my experience with two-high and three-high mills. I told him, "If you will come over here, we will be pleased to send you back a wiser man than you came." If you take a plate and roll it all on the same heat, you will get a better plate than where you take and roll that one way, and then re-heat it and roll it again. I have taken wide plates, where they were pulled out in all directions 100 in. wide, and tested them lengthwise and crosswise (I have tried scores and scores of them), and found very little difference; whereas in many English plates you have a considerable difference. That is why, in the British government tests, you see 60,000 and 62,000 with 27 per cent. elongation. It is because the inspectors are very nice gentlemen and do most of their testing lengthwise. If they ask for a cross test, then it may not show up quite so well.

I do not know whether I have made that clear in my statement. I was afraid of making the paper a little long, so I cut a good deal out. But I think that is the reason. I do not attribute it to any-

thing else. I do not attribute it to *chemical analysis* altogether. I think myself the three-high methods are a long way ahead of the old two-high methods.

I think the difference is entirely in the metal and manipulation or handling and rolling. In regard to the analysis, when you put your manganese into the furnace, you naturally get less manganese than you do in the ladle. In some mills they still put it into the furnace. My practice in Scotland was to grind it up fine (pieces about the size of my thumb), and then feed it gradually into the ladle, and I would get 7 to 8-10 manganese; whereas here we only get from 4 to 5 tenths.

MR. BAILEY: I have had no experience in open hearth factories, although I read Mr. Koch's paper with a great deal of interest. I notice the gentleman shows a difference between transverse and longitudinal tests. I can say that we have never had that experience with Bessemer steel, but I do not know how it would be in open hearth.

MR. REESE: In looking over the paper of Mr. Koch, this evening I notice on the first page he says: "In 1869, curiously enough, basic bottoms were recommended by M. LeChatelier, a great French metallurgist, and bottoms of lime and dolomite were tried, but after a while sand was found to stand the best, and it was far easier to repair; now the basic bottom is coming to the front again."

Now, I wish, in that connection, to read to you an extract from the Opinion of the Commissioner of Patents of the United States Court in a patent case. It is from the case of Harmet et al. *vs.* Reese.

EXTRACT FROM COMMISSIONER MARBLE'S DECISION IN CASES A AND B, REESE *vs.* S. G. THOMAS ET AL., MAY 24, 1882.

"The Examiner of Interferences and the Board of Examiners-in-chief concur in finding that Jacob Reese practiced this invention as early as 1867. An examination of the testimony leaves no doubt that, as early as 1866, Reese had a plant (illustrated in the sketches offered in testimony) which consisted of the various appliances necessary to the practice of this invention. There was a cupola, beneath which was the first converter, lined with brick or silicious lining, and in convenient proximity a second converter,

lined with lime or basic lining, and also an open hearth furnace, lined with a basic lining. * * * Upon the whole case I find that Reese is the prior inventor."

That is the decision of the Commissioner, that Reese had these things in 1866, and that the invention was then perfected, and thus was three years ahead of this French doctor.

I think Mr. Koch's paper an excellent one, and I have no doubt it will be of great benefit to the trade. It is a paper which does the gentleman great credit.

During the war I had a contract with the government for 10,000 tons of armor, to stand a tensile strength of 60,000 pounds to the square inch.

I found in testing the plates they generally ran from 3,000 to 5,000 pounds less in tensile strength when tested crosswise than they did when tested lengthwise.

I agree with Mr. Koch, that the difference between English and American steel is entirely in the method of rolling.

MR. A. E. HUNT: I think in reference to what Mr. Reese had said, he answered himself, in that Mr. Koch had well explained to us that the difference in rolling was one of the particular reasons for the difference in the results we get in elongation. We all know that when Mr. Rodd, or any of the other engineers here, make requirements of their specifications for bridge material, they allow a different tensile strength and a different amount of elongation for a test taken lengthwise than they do for a test taken crosswise. This difference is more marked in iron than in steel, because the difference in rolling is more marked with iron than it is in steel; but the same thing occurs in steel. As Mr. Koch has said, if you want to get good results with steel, you must take the metal according to the steel manufacturer's way of preparing specimens with the grain, although, with the three-high plate mills and the improved methods of rolling, they do get sometimes nearly as good results transversely with steel as they do longitudinally. I think that is one of the strong reasons why, especially for structural purposes, we should use steel for wide plates instead of iron.

When it had been reckoned that iron had, for instance, 50,000

pounds tensible strength, 30,000 elastic strength, per square inch, it often occurs that they were not getting anything like the results the engineer expected he was getting; that is, not getting the factor of safety, on account of the plates having been put the wrong way with the grain of the metal, so that the strain came transversely on the fibre of the metal instead of longitudinally. That is one of the things inspectors have to look out for.

I am very much interested in Mr. Koch's paper, and I would like to ask one further question, that is, as to the size of the furnaces that were first built. I do not think Mr. Koch gave the tonnage, whether they were three ton or five ton, or big forty ton furnaces like they are building to-day. A little history of the gradual increase of the size of furnaces may be interesting. It would be to me, anyhow.

MR. KOCH: The first furnace was about a ton; it was a little furnace, and was constructed in the corner of a back yard in Birmingham. The first furnaces built were what we call five ton furnaces in practice, but you could melt about seven tons in them. Then they grew very fast. We soon got up to twelve and fifteen. First we had a twelve ton furnace. I think I have a drawing of it yet. It was built in 1871 or 1872. But the old works at Landore were the first. There was a five ton furnace, a seven ton furnace and a two ton furnace; then there was a furnace of twelve tons.

MR. HUNT: What is the largest furnace?

MR. KOCH: They built one in Landore which they called a 100 ton furnace. It had two tapping holes. I was told they got about 90 tons of metal melted in it, then they had to tap off the first hole, leave so much in and fill it up again; I believe this failed. The biggest furnace I ever built was a 22 ton furnace.

MR. ROBERTS: I have been very much interested in this discussion, about the effect of rolling on the transverse and longitudinal strength of steel. The question seems to me to be very important in connection with boiler plates. The greatest care should be taken to have the plates properly rolled. This might account for some of the disasters we have had—defects in the boilers. In all the discussions we have had in our Society about boilers, that point was never brought up about the manipu-

lation of the material. They always turned on the theory of high and low water.

MR. RODD: So far as the bridges we build are concerned, we have found iron to answer our requirements. Iron has certain advantages for the class of bridges we build, namely, railway bridges, and it gives them weight.

Some forty years ago, I find, in old English Parliamentary Reports, that the Board of Trade had certain investigations made as to the behavior of girders under moving loads having varying proportions, as between load and girder weights, also tests were made as to the effect of speed; it was found that the greater the moving load, the greater would be the deflection and vibration of the girder; also, that the greater the speed the greater the vibration. There is nothing new in these general propositions, and they agree thoroughly with the results of experience; therefore, I take it that as we have been endeavoring for many years to utilize wrought iron, with a reasonable successful result, we would do well to hold on to wrought iron for our bridges of moderate span, especially railway bridges. Everything points at present towards the coming of steel, but as we are doing fairly well with iron now, and as weight is really an advantage to a railway bridge, and further, because there is no great obvious advantage in immediately taking up steel and discarding wrought iron, while there are certain elements of doubt as to its use, I am in favor of using wrought iron for railway bridges of ordinary span. We are gathering experience every day as to steel, but when the day comes, as very likely it will, when steel will be used for our bridges, even then my feeling is that we should not use it as a means of saving dead weight in railway bridges of ordinary span.

Too much stress is laid on the fact that steel is found to give remarkably good results in the testing machine, both in small tests and in full sized members. There is a difference, and a very marked one, between the work a piece of iron does in a bridge as a part of the bridge and the work it does in a machine.

We have used mild steel in certain places in our bridges, such as bent plates for making connections, using the same unit strains as for wrought iron; I have had no instance of any trouble from its use.

For highway bridges and roofs, the use of steel will no doubt result in a saving. In the case of a highway bridge properly built the load for which it is proportioned will never, probably, be placed upon it, and generally the load it receives is insignificant as compared with the load for which it is built. In a railway bridge, on the contrary, every time the bridge is used it carries a load approximating that for which it is proportioned.

We still have a great deal to learn as to the value of material in active service in structures. The only guide in which we can have confidence is the result of experience.

MR. HUNT: I might relate, as an illustration of what Mr. Rodd has just said, an incident occurring with one of the largest bridges that has been built. They had a long section in the bridge shop consisting of two six by six angles, and they were lifted and held up by a chain from a crane. They had just lifted them about three inches from the shop floor, when a link of the chain broke, and the angles fell about a distance of three inches, and those steel angles snapped off like pipe stems; and yet specimens of the steel from the same angles, near the fracture, have since stood a remarkably good test.

MR. REESE: I think it is possible, and not only possible, but it seems to me highly probable, that we should make fibrous iron by the fluid process, both open hearth and Bessemer. I have succeeded in a small way (500 pounds) in making the most beautiful fibrous steel that I have ever seen. I never saw fibrous iron equal to it. In tests, where it was put under the hammer, it doubled up in an S form, and pulled out like hickory withes. I would have tested it long before this, had it not been that the matter is in that wonderful cauldron—the Supreme Court—and I do not propose to put anybody to trouble, or trouble myself, until I know who is going to get it. I would just like to add, that I think it perfectly feasible, and highly probable, that we are going to make fibrous iron, both in Bessemer and open hearth.

MR. STAFFORD: It seems to me the difference in melting should have some difference on the elongation. I know our Welsh and Scotch melters are inclined to run their steel much hotter than we do. Our practice is to run the steel quite cold, whereas they run it quite as hot as it will bear. For that reason

I think a probable difficulty would be this development of fibre, and the rolling in one direction would increase that, or rather that would have its influence in giving an elongation with the same tensile strength.

MR. KOCH: I do not know whether I can answer that question as regards "our Scotch and Welsh melters." The first thing I have to do with new melters is to get them to cool the metal. It is quite possible it would make a difference, but I have really no data by which to calculate it. It is a practice I have always discouraged on this side of the water.

There is one point I would like to mention, and that is, on page 48 I say, "I believe that failures in deck and I beams are caused more by pinching and cold straightening, forming hard places in the steel, than by any other cause except excess of phosphorus." That straightening is the very mischief. I remember when we first rolled deck beams for the British government, we were loading on what we called a double bolster car. In loading one fell on the other side, and it broke into three pieces, and the exact places where it broke was where it had been cold straightened; it was right on the punch mark. Those were some of the first beams made. These difficulties, it seems to me, are caused almost entirely by excessive and careless cold straightening.

MR. REESE: The specification should come in there also. In straightening rails, where we straighten the rails cold, while they were just warmed enough that they would not burn the men's hands in handling them, we had no trouble. When the bell would ring on Saturday afternoon, say at 1 o'clock, everybody would drop their tools, and they would leave, may be, four, five or twenty tons of rails on the bed. Then they would be cold on Monday morning, and when they would come to straighten them they would break many of them. So, in making out specifications for steel, I would suggest that the cold straightening be done not below a temperature of 100° Fah., then no cracking and no trouble would ensue.

MR. BRASHEAR: As I have said in this Society more than once, I think that there is such a beautiful corollation among all subjects in nature that we can study every one with pleasure.

For instance, take glass. You possibly all remember when Bastiat made his memorable discovery.

For a time the Bastiat tempered glass created great excitement in all the world. Then it was found that Bastiat tumblers, standing upon the table, would sometimes burst into atoms—and when they did burst, they always burst into atoms—and very serious injury followed the use of the glass. Siemens undertook to carry the thing further. He claimed the reason the Bastiat glass burst was because it was unequally annealed, when the fact was, it was not annealed at all, but just the reverse, *put* in the condition of steel when it was hardened. He read a paper before the Royal Society of Great Britain, explaining the method by which he would anneal his glass (or harden it, if you please), equally in all its parts.

My professor asked him, "Did you ever look into your glass with polarized light?" He hung his head and said, "Yes." "Well, how did it look?" "There were some strains there." The fact of the matter is this, if we could look into our hardened steel, and steel in the condition of tempering, and see the condition in which it is put, by which the molecules are not allowed to fall into their normal condition, you would see strange things there. I believe these tensions are in every material that does not allow the molecules to find their proper positions.

I believe there is in this thing not only a normal condition in which we must place our materials, but in the kind of fibre of which our friend Mr. Rodd has spoken. This question of fibre has a very great part to play in the consideration of the subject. You know, if you take rails, which may have a tensile strength of 500 or 1,000 tons to the square inch, ride them up and down two or three times, and if the ends of the fibres are not right, it will shatter them all to pieces. I think there is in this a beautiful study, and I wish I had the time to study it more than I do.

MR. REESE: I really believe that is where the trouble lies, but as you all laughed at me when I spoke of molecules the last time, I thought I would not mention them to-night.

If you will consult the advanced physicists — I do not care whether on the other side or this side—they will tell you the matter is in the physical molecular construction of the metal. There is the whole secret of the thing. At our next winter meet-

ing I would like very much to have the question come up for serious consideration.

I would say here, that this is in advance of the age. You know how it is with men who are in advance of their age. They rise up like a mushroom, and if you don't knock them down, the sun withers them. The man who goes in advance of his age, goes there to be knocked down.

I suppose all of you may not know that the reason you call pig metal by that name is because the name of its inventor was Ralph Hog, and the metal was called pig metal in derision of him who was its inventor. It is a matter of history that Ralph Hog was the inventor of fluid iron.

Then, poor Dudley, when he went into the blast furnace business, the best furnace in the world produced a ton a week. He brought it up to a ton a day, and they mobbed him and put him in the Tower of London, and kept him there until they starved him to death.

MR. ROBERTS: I concur with some of the remarks that have been made, but certainly they do keep the engineers in a stew. Recently they got us to believe steel was the thing; to-night they tell us a little cold bending will weaken or take all the strength out of a bar of steel. It seems to me that in such cases it is not properly manufactured. Now, my friend here is one of the men to whom they should listen, because he is a manufacturer of steel. For structural purposes, the last time I heard Mr. Metcalf speak on the subject, he said to use high steel. The year before he said low steel; so I do not know exactly where the civil engineers can safely stand on this question.

MR. BRASHEAR: In regard to the discussion of the result of taking a position in advance of the age in which one lives, I would say that about two years ago I visited Dr. John Draper, whom you all know as the author of "The Intellectual Development of Europe," and that other work, "The Conflict Between Science and Religion." His son, Dr. Daniel Draper, who is now Chief of the Meteorological Service in New York, told me this. Said he, "When my father finished that work (I was his amanuensis), we sat down and read it over together. After the work was finished my father said, 'Daniel, we must cut it; the world is not

ready for all that yet.'" Daniel begged him not to cut it, his friends begged him not to cut it, but he eliminated 400 pages. They read it a second time. The old gentlemen said, "Daniel, there is too much there yet; the world is not ready for it; we must cut it again." And where it originally occupied about 1,700 pages, it was cut down to 900. It is a memorable work, which will always be known as a masterpiece. In that work are advanced ideas. The world may not be ready for them, but this Engineers' Society and other societies are.

While we may not now be known in the world for anything but natural gas, iron, etc., let us be known to be investigators and originators, to discover some new fact worth all the old facts put together.

The discussion was postponed.

A communication from the Engineers' Club of Kansas City, asking our co-operation in the effort to bring about Government inspection of bridges, was received, and together with a request from the Western Society of Engineers, was referred to a special committee, consisting of A. E. Hunt, Thos. Rodd, Chas. Davis, G. Lindenthal and F. C. Osborn.

On motion of A. E. Hunt, a resolution commending the establishment of a technical school in connection with the Western University of Pennsylvania, was adopted.

The death of David A. Smith was announced, and a committee appointed to report at next meeting.

On motion, it was

Resolved, That, as our esteemed fellow member, J. A. Brashear, intends to start soon to Europe, we extend to him our well wishes on his journey, and instruct our President and Secretary to give him a letter of introduction to the engineering societies wherever he goes.

On motion, Society adjourned to third Tuesday in September.

S. M. WICKERSHAM,
Secretary.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

This Society does not hold itself responsible for the opinions of its members.

PITTSBURGH, Sept. 18th, 1888.

Society met at 8 o'clock P. M. at rooms; Vice-President W. L. Scaife in the chair.

E. P. Taylor, T. P. Roberts, of the Board, and thirty-seven other members being present.

Messrs. A. E. Linkenheimer, L. J. Hohl, T. H. Colin, Jno. G. Parke, Jr., were duly elected to membership.

Under the head of unfinished business the President called for remarks on Mr. Koch's paper, and asked Mr. Hibbard if he had solved the conundrum propounded by Mr. Koch, to the effect that considerable variations or changes in steel were due to the use of a universal mill.

MR. HIBBARD: I do not think I have. I do not believe that is the cause. I listened to what he said about it at the time, but I could not reconcile it with what had come under my observation, though I do not know that I have anything to advance. There are a good many phenomena of that sort in the making of steel, and its working, which I cannot explain, though I have been at it for ten years pretty steadily; but I think when the real cause of this difference in qualities in apparently the same composition chemically is discovered, it will be found to be something affected by the treatment in the open hearth furnace itself.

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I think it will probably be in connection with the quantity of oxygen in the steel, both in the finished steel and during its manufacture, but beyond that, I would not trust myself to say anything, for I have determined as yet nothing satisfactory to myself even. Yet I think it is to be found in something besides the mechanical treatment, and that when a true method of determining the oxygen in steel is found, we shall know a great many things that now seem to be mysterious.

MR. SCAIFE: You think then the mechanical operation has not much to do with the final result?

MR. HIBBARD: I do not say that at all, but in the case referred to, it does not play so important a part as the treatment in the open hearth furnace. The physical properties of steel can undoubtedly be greatly changed by the mill and the physical working that it is subsequently subjected to, but I do not think that accounts for it all.

In reply to a question concerning the effect of oxygen in steel,

T. R. PHILLIPS: There is a supposition that oxygen occurs in steel, apparently based on facts. Exact methods for the determination of oxygen in steel are hardly possible, however, and until the proportion of oxygen can be accurately stated, I do not see that its effects can be defined.

The paper of the evening was by Mr. Edward J. Aikman, which was read by E. B. Taylor, on

THE JANNEY COUPLER.

The car coupling has long claimed the attention of railroad men, and justly so, involving as it does the safety of men handling cars, the entirety of the train when in motion, the security of stock and merchandise in transit, and last, but by no means least, the stopping of trains when desirable. From the diversity of interest involved, the selection of a uniform or standard coupler has been very difficult. The brake tests carried on at Burlington, Iowa, during '86 and '87, swept away many theories long held as axiomatic, and resulted in the selection by the Master Car Builders Association of the United States and Canada of the vertical plane or Janney type of coupler as the standard of the Association. This selection was confirmed by letter ballot.

Several of the trunk lines have recently applied the Janney in large numbers during the last year, and the indications seem to be that the time has come when a united effort will be made to introduce a uniform style of coupler that will be entirely automatic in coupling, that can be uncoupled without the necessity of a man going between cars, that will give a fastening strong enough to keep trains from breaking in two when running, that will have the least practicable amount of slack between cars, thus avoiding shocks when in motion from irregularity of roadway, and that will enable freight trains to be stopped and started as a whole, as in passenger service.

The principal parts of the Janney Coupler are: the coupler proper, *i. e.*, the head and barrel, the knuckle or hook, and the drop pin or catch which holds the hook when coupled. The coupler is substantially the same for freight as for passenger cars; the contour lines are alike, and each will couple with the other, the only difference is that the material is thicker and the head deeper in the freight than in the passenger. As the passenger coupler has been in use for so many years and is probably somewhat familiar to those present, the following details will only refer to couplers for freight service.

What is designated as the coupler, *i. e.*, the head and barrel, is made of malleable iron and weighs 148 lbs.

The knuckle or hook in freight service is an hydraulic forging, in passenger service it is made of cast steel. The knuckle pin or pivot on which the knuckle rotates, is of crucible steel $1\frac{3}{8}$ in. diameter. The drop pin that holds the knuckle in position when coupled, is of malleable iron, as are also other small pieces. The weight of a coupler complete is about 210 lbs. or 420 lbs. per car, and the cost is $25.00 per car, including all parts necessary for the uncoupling rig.

The blue prints submitted herewith show the parts in detail and give the various dimensions; they also show the manner of applying and the various devices used from time to time in the uncoupling rig.

The coupler is $33\frac{1}{4}$ in. over all, is 30 in. from inside of knuckle to tail end, and is $21\frac{1}{4}$ in. from back of stop to tail end. The

barrel for 6¼ in. back from the head is 5 in. square, this is where it rests in the stirrup, the remainder is 5 in. in diameter. These dimensions are standard with the Car Builders Association. The stop is placed 21½ in. from the tail end and acts as a buffer against the end sill of the car to relieve the draft rigging in drilling or stopping. The average thickness of the metal in the barrel is ⅞ in. The head in which are the parts forming the coupler projects 12 in. beyond the stop. The right side is in the general form of a square with a rounded corner in which the knuckle is placed. The left side curves outwardly forming a guard arm used to guide the knuckle in coupling and to prevent too great lateral motion when in use. Lugs on the right side hold the knuckle; the upper lug is heavier than the lower, as it receives most of the blows from cars equipped with a common link and pin draw-bar when in use. The lower face of the top lug forms a stop to prevent the knuckle from passing beyond the center of the coupler in opening. The knuckle in general shape resembles a T bent at right angles just below the top. It is 9 in. deep, 3 in. thick and 3 in. wide, and is pivoted on the knuckle pin passing through the lugs on the head. The tail end of the knuckle passes into the head and is held by the drop pin on which it has a bearing of 2½ in. The cross piece of the T in the knuckle is divided into two lugs by a slot in which a link is fastened when coupling with cars using link and pin. The lugs are drilled to allow the passage of a coupling pin. The upper lug is 4 in. deep and the lower 3 in. This difference is made because the upper lug receives the greater number of blows in service. The depth of the knuckle allows a variation of 7 in. in height of cars. The Janney type of couplers allow vertical motion, hence there is no lifting up or pulling down when cars are of different heights, and the strain on the draft rigging is greatly reduced. The inner face of the knuckle is laid out on a system of circles, so that when coupled they act on each other after the manner of cog wheels, and the tendency is to pull to the center whether on a straight track or a curve. These circles form what are called the contour lines of the coupler. The drop or locking pin is in the rear of the head near the stop mentioned heretofore. The upper half is square, the lower oblong. Where the square

and oblong join is an inclined surface facing the centre of the coupler. A similar inclined face is on the outside of the tail end of the knuckle. When the knuckle is caused to rotate in coupling, the inclined face of the tail comes in contact with the incline on the pin, and the latter is raised, allowing the tail of the knuckle to pass when the pin drops into position and locks the knuckle preventing its return or uncoupling, thus forming a simple and most effectual locking device. The drop pin extends below the head. On its lower end a shoe is placed in which a rod passing under the end sill acts, by means of which the pin can be raised from the side of the car and the knuckle allowed to rotate to uncouple. The shoe also acts as a weight to cause the pin to drop into place rapidly after being raised by the knuckle. The lock acts by gravity and requires no springs. The knuckle coincides with the inner surface of the head in such a manner that the shock of all blows is transferred from the knuckle to the casting, and no strain is brought on the knuckle pin. The drop pin bears against a solid casting and is relieved of all bending strains in pulling.

The uncoupling lever is a rod 1 in. in diameter passing under the end sill and secured to it by malleable holders, it is bent at four points. A piece of $\frac{1}{2}$ in. x $1\frac{1}{2}$ in. iron is welded in one corner. This fits in one of the holders and keeps the device uncoupled when so desired.

A few changes have been made since the couplers were first used in freight service, principally in the uncoupling rig, with a view to simplifying the device; these are shown in the blue prints.

The coupler is applied to the standard M. C. B. draft rigging.

Several changes have been made in regard to the use of springs. When first applied on heavy refrigerator cars, a buffer spring was used to take the blow in stopping and an auxiliary draft spring to give the supposed necessary slack in starting. The tests at Burlington eliminated both. The buffer spring was compressed by the blow, and would cause the car to recoil after the first impact, giving two shocks in place of one to each car. The auxiliary draft spring gave too much slack.

The special train made for the Westinghouse Air Brake Co. was equipped with Janney Couplers and had buffer and auxiliary springs

at first; these were removed en route to Burlington. During the tests there, and throughout the triumphal tour after, the cars were equipped with only a standard 8 in. draft spring.

The Janney Passenger Coupler has been in use for the last eight years and is now doing service on over 150 different lines. The contour lines of the passenger coupler are the same as those of the freight, and trains composed of passenger and freight cars mixed are run daily over several roads. A catch inside the head, pivoted on hexagonal pin and actuated by a coiled spring, also in the head, holds the knuckle when coupled. The catch can be released by a lever working from the platform by means of a pull rod and button connecting with the pivotal pin. Two buffers are used, one flat and one round face, thus ensuring an equal bearing when running on curves. The stems of the buffers rest in the two arms of an equalizing bar that is pivoted at its center, allowing the buffers to severally advance or retire so as to engage those of the car attached whether on straight track or curves. By this means an equal bearing is always obtained on the buffer faces and the train made more continuous.

The Miller platform has only one square buffer placed rigidly in the center. In running on curves only the sides of opposite buffers engage, and the rigidity of the train is impaired. In erecting, the buffers are set so that when two cars come together to couple they will engage before the coupling is complete, making the train solid when coupled. By means of a yoke lever the action of the buffers is communicated to the coupler, and the draft spring used as an auxiliary to the buffer spring in stopping. The same arrangement utilizes the buffer spring in starting, giving a total spring resistance of 19,000 lbs. in stopping, and 29,000 lbs. in starting.

The coupler operates on any curve over which a car can be passed and has never been known to uncouple. As the hooks are entirely surrounded they meet resistance in all directions, hence the tendency of cars to telescope is in a large measure obviated.

The blue prints submitted herewith show the coupler and buffer attachment in detail. The price of the Janney Passenger Coupler is ~~$90.00~~ per car, this includes all parts necessary to its working.
100.00

In practice it was found necessary in many instances to couple cars together that were severally equipped with the Miller and Janney couplers. To meet this requirement, what has been termed the Janney-Miller Combination Coupler is used. This is substantially two complete sets of couplers and buffers, viz: a Janney and a Miller. The Janney is made in two pieces, the head forming one and the barrel the other. These are tongued together and held by a pin. A Miller hook is made, the rear end of which corresponds to the rear portion of the Janney head. When the Janney head is removed the Miller hook can be inserted in the end of the barrel. A buffer corresponding to the Miller buffer is made, which, by means of the yoke lever, acts in connection with the draft spring. The labor of changing from a Janney to a Miller, or *vice versa*, can be performed in from fifteen to twenty minutes. These couplers are used largely on Pullman and private cars. The price for Janney-Miller Combination Coupler is ~~$150.00~~ per car, and includes 160.00 all parts necessary to its working. The blue prints submitted herewith give the parts in detail.

A special pattern is made for tender or tank couplings in which the device is substantially the same as in freight service. These are bolted on the tank frame, take up no more room than a link coupler, and require no extra platform as does the Miller.

In the discussion which followed the reading, Mr. Roberts said: I suppose there is no member of the Society here who is not aware of the fact that the subject of car couplers is one of very great importance, and one that inventors have been working upon for many years, but so far, however, there has been no approved device that has been generally applied. All that information is well known among the professional men, and even among the readers of the daily newspapers, outside of the profession.

Now one point struck me in the paper on which I would like to ask for information. The writer has not elaborated the point, but there may be some persons here who could probably answer it. The writer refers to the advisability of having great rigidity in the movement of freight trains. I have not been connected in recent years with any railroad operations, but have entertained the no-

tion that on railroads with undulating grades there was some advantage in having link connection in the making up of trains, so that a moderately heavy locomotive that will get a fair headway can do so better with the link motion than if the train was entirely rigid.

MR. TAYLOR: It was generally supposed that it was necessary to have plenty of slack in order to start a train on a heavy grade. The tests at Burlington, however, developed that the less slack the better, that a train thoroughly coupled with tight couplers started easier than that with the link and pin couplers.

MR. HARLOW: Still they put brakes on last car and jerk along.

MR. BECKER: That is because they have no Janney couplers on freight cars.

MR. ROBERTS: I can see the point that there would be a slight reaction from one car to another, referred to by Mr. Harlow, which might have its effect on the power of the locomotive. For each time that the link was taken up the reaction would be felt by the locomotive.

This is an important point, and I think it is curious that the writer of the paper did not dwell more upon it. Now, I have been told by locomotive engineers, that when the Janney Coupler was first put on passenger trains they lost time in the starting. I know that in the case of certain Wisconsin roads, they always had that difficulty. And now the statement is made that with increased weight on the locomotive, and an increased number of cars in the train, that we can start a larger load easier than a smaller one, and I think it is important to know how it is done.

MR. BECKER: I remember distinctly that special reference is made to this matter in the report of the "Master Car Builders' Association" on the "Brake Tests" made at Burlington, Iowa, about a year ago. The tests were made for the primary purpose of ascertaining the best and safest character of brake for freight traffic, and although the question of "Couplers" was only an incidental matter, yet it had such a large influence upon the results, that the "Coupler" question was dwelt upon quite extensively in the report, and if I recollect right, the vote which was taken finally by the members of the Association showed a decided preference in favor of the "Janney" type of coupler.

I can safely say that it is universally conceded, not only by railroad managers and by employees of the rolling stock departments, but also by the manufacturers of railroad appliances, that the tests made at Burlington were conducted on a more thorough-going, intelligent and impartial scale, than anything of this kind ever attempted heretofore in this country, and I do not think that there has been a solitary remonstrance made, or fault found, by any of the competing parties interested in the trial, but that, on the contrary, the absolute fairness of the proceedings is universally admitted.

I am so fortunate as to know personally Mr. Godfrey Rhoads, who had personal charge of the tests, and if there is anyone competent to conduct such operations, Mr. Rhoads is the man. The result of the tests demonstrated, as Mr. Taylor says, that with this vertical plane coupler, the old custom of backing up and putting one car into motion after another has been thoroughly exploded, but the result could, of course, have only been shown by the employment of a coupler like the one here described, and would not have been practicable with the old link and pin appliances, because there was no rigid connection possible with those fixtures, excepting by wedging, and that was hardly ever used in freight trains, although it was sometimes used on passenger trains before more modern types of couplers came into better use.

I will try to procure a copy of the Report of the Committee of the Master Car Builders' Association on the Burlington Tests for the library of the Society, and anyone interested in the subject will find it worth reading.

MR. SCAIFE: Do you know whether in these tests the engines hauled the maximum load?

MR. BECKER: I think they did. I know that the Committee spent weeks there, and the tests were on the most comprehensive scale. Trains fully equipped for the purpose were tested on all kinds of grades and curves, and under every possible condition that would present itself in actual traffic, and the whole operation was so exhaustive in its character that it may well be considered as conclusive. Preparations were made on a very extensive scale, and a large amount of money was expended, not only by the C., B. & Q.

R. R., but by other parties, because it was a general problem that needed demonstration, and in which all railroads were more or less interested.

MR. PRICE: We must bear in mind with reference to the point made by Mr. Roberts, that even with the Janney coupler, or any form of tight coupler, there must be a considerable amount of slack, namely, that which comes from the draft springs. While there is the absence of that jerk which, in the present form of link and pin coupler, leads to the breakage of links and pins, yet with the Janney or any other form of tight coupler, we will retain the entirely unobjectionable, and, in fact, really desirable, spring slack, helping in the starting of heavy trains.

MR. SCAIFE: You substitute a spring motion for a shock. In the one there is very little loss of power, in the other a great deal. This is somewhat similar to the application of springs to the traces of horses on street railroads, etc. I heard a gentleman who has had some experience in the moving of vehicles over rough roads say, that by the use of springs about 25 per cent. of power was saved in some instances.

MR. PRICE: I think that would illustrate the advantage of the tight over the link and pin coupler.

MR. ROBERTS: These statements are very important.

MR. SCAIFE: Would it not seem that there is a limit to the stiffness of the springs; that is, a certain point at which the additional stiffness would reduce the hauling capability of the locomotive instead of increasing it?

MR. PRICE: Yes, sir, I think so; I presume the manufacturers of these tight couplers have taken up that point and have come near to the proper limit.

MR. HUNT: There is a party in Pittsburgh that are making a whipple-tree that they claim by the use of a spring that a horse can pull anywhere from 1,000 to 2,000 lbs. more than it would without the spring. That seems to illustrate this point.

MR. ROBERTS: I think the spring idea is an excellent one. Of course everything rests in the moment of inertia of each car, and dividing their weight by the time, etc. In the operation of our locks, the Monongahela Navigation Company has in the past tried

springs, and barring the cost of repairs found them excellent. The difficulty with them was in the mechanical construction, and they were abandoned for that reason.

I see the force of what has been said about this taking up the motion in the couplers in addition to the elasticity of the car, and then partly in the springs connected with these couplers. It is all a new point to me and answers my question.

We cannot do too much to encourage railroad companies to adopt some system of this sort, and thus save the lives of their brakemen. I believe that statistics report that about three brakemen are killed in the United States every day, and probably ten times that number injured, and it is a question of very vital importance, and I think any action our Society could take to encourage the development of this system on railroads would be an excellent thing.

MR. TAYLOR here read an extract from the *Railroad Gazette* of April 8th, relative to the tests made at Burlington.

MR. PRICE: I think that the case just read is quite conclusive as to the real value of the spring over the link and pin slack. It is a fact that the link slack in that train was entirely eliminated by placing blocks in the links, yet with the help of the spring slack they could start as well as, if not better than before.

MR. ROBERTS: Can these couplers be connected at either side as well as at the top?

MR. TAYLOR: The couplers are right and left; by means of the levers, as described, on each end of the car, there is no difficulty in coupling or uncoupling.

MR. ROBERTS: The price, $25 per car, seems reasonable.

MR. TAYLOR: That does not give the cost of applying it to the car. You will have to make some changes to adapt it. I think it runs from $60 to $70 complete.

MR. TAYLOR here read another extract from an editorial in the *Railroad Gazette* of January 28th, 1887.

MR. ROBERTS: I think it might be interesting to say something about the durability of these couplers. It is said in the paper about its being in use some eight years.

MR. HIBBARD: There is something to be said about the dura-

bility of this coupler. I understand from the paper that it has been in use eight years. In that connection I will say that I have recognized some of these castings in our scrap pile to be re-melted. There are probably several tons of them. It may be because they are worn out or due to some alteration in design. I will examine more carefully.

MR. TAYLOR: I think you will find they are worn out. The service they are called upon to perform is very heavy, and they break frequently in freight service. Yet on this train fitted up by Westinghouse many thousands of miles were made, and there was, I think, only one coupler broken in all the experiments from the time the train left Altoona until it got back, and it was handled very roughly at times.

MR. ROBERTS: That hole through this movable link, I presume, is merely there to make the existing link and pin connection when necessary, and if the system be adopted it will be done away with and that will no doubt help the life.

MR. TAYLOR: Yes, you are right about that. I think that the passenger coupler has not depth enough; the freight coupler is deeper.

MR. HIBBARD: In the matter of these castings it is found from analyses that the carbon varies from .30 to .75. That is an important matter to watch. Steel of one of these carbons should be better than the other.

MR. BECKER: The only trouble I ever remember as being caused by the "Janney" coupler occurred when postal cars, which are exceptionally long, were coupled to other cars or to the tenders of engines whose attachment was of different elevation from that of the "Janney" on the postal cars. In such cases, when going around sharp curves, in one or two instances that I know of, the truck nearest to the unequal attachment was lifted bodily off the rail in passing through frogs or crossings at points where the angle of the crossing frogs would not admit of the introduction of safe guard rails.

MR. TAYLOR: The Janney type is undoubtedly correct, but the question is, whether the Janney coupler is best of that type.

MR. PRICE: I understood the writer to say that it was about

eight years old. It was used in the Pennsylvania road during the centennial, which would make it about eleven years old, on the P. R. R.

Further discussion was postponed until next meeting.

The meeting adjourned about 9½ o'clock.

S. M. WICKERSHAM,
Secretary.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

This Society does not hold itself responsible for the opinions of its members.

PITTSBURGH, Oct. 16th, 1888.

Society met at 8 o'clock P. M. at rooms; President A. Dempster in the chair.

Vice-President Scaife, Directors A. E. Hunt, T. P. Roberts, Charles Davis, and thirty-six members being present.

Minutes of last meeting were read and approved. Henry M. Howe, of Boston, Mass., was duly elected a member.

The further consideration of the paper of Mr. Aikman on the Janney Coupler being in order, was opened by

MR. MAX. I. BECKER, viz.: As further contribution to the discussion of the paper read last meeting on the Janney Coupler, I would refer the members of the Society to the report made by the Committee on the Janney type of car couplers to the Master Car Builders' Association. This report is published in the Transactions of the Association at their annual meeting held in Minneapolis in June, 1887.

On pages 187 to 196, inclusive, the Committee sets forth that out of 4,000 patented devices about one half-dozen have been finally selected as worthy of recommendation for adoption, and these were all of the Janney type, with vertical planes, close-fitting, and spring slack only. The old-fashioned loose, slack coupling was considered impracticable in connection with power brakes, unless they were applied electrically, and to each car individually and instantaneously.

It was also found that the greatest effort of the engine was reached after all the slack was taken up and all the cars in the train had been started; that on an up-grade of say 52 feet per mile it was found that the train closely coupled could be more easily started than a loose coupled one, for the reason that with the loosely coupled train an engine could not be started with full force, for fear of breaking couplings and causing disastrous shocks to live stock and valuable freights.

All these conclusions are based upon careful investigation and observation, accompanied by extensive tests. During the ensuing discussion, subsequent to the submission of the Committee's report above referred to, on pages 199 to 208, the facts as stated are generally corroborated, and it was finally decided to submit the question as to what type of coupler should be recommended for adoption to a vote of the members of the Association by letter ballot. On pages 106 to 112 are recorded in great detail the results of a number of tests made at the Burlington trial with and without slack. On pages 209 and 210 of the Proceedings will be found some interesting statistical information relative to accidents incidental to railroad traffic. According to this information, about 1,400 employees are killed and about 6,500 are wounded annually in the United States by coupling cars. In the discussion on the drawhead, pages 220 to 224, it was suggested that in order to pull the train easier the spring slack be reduced by shortening the coupler springs and making them correspondingly heavier, so as to preserve their effective strength.

The final ballot of the members of the Association resulted in the casting of 474 votes in favor of the adoption of the Janney coupler type, and 194 against it.

On pages 246 to 252 will be found a tabulated result of the votes cast. Each car manufacturing company, transportation or railroad company, owning one thousand cars or less, is entitled to cast one vote, and one additional vote for each additional one thousand cars owned by the company, road or association.

I take pleasure in presenting to the library of the Society a copy of the Transactions of the Master Car Builders' Association at their annual meeting in Minneapolis in 1887, which contains, in addition to the subject matter under discussion, much other valuable

information well worthy a perusal by such members as take an interest in matters of this kind.

MR. SCAIFE called attention to the fact that a gentleman who had patented a type of coupler was present, in the person of Mr. Simpson, of Carnegie, Phipps & Co., Limited, and being called upon,

MR. SIMPSON said: I do not consider that what I have is an improvement upon the principle of the Janney drawhead. It is an improvement in the material, in the lock here, which does not alter the principle. The lock, instead of being malleable iron, is of forged iron. I was some time ago impressed with the idea that this hook requires to be forged. I considered that it must be a difficult matter to make the malleable casting, and after considerable time and labor I conceived the idea of a forging, and that is the only improvement. The lines of contour are just the same exactly.

(Mr. Simpson here exhibited a drawing of his coupler, which the members examined.)

MR. HUNT: How do you make this forging? That seems to be a difficult thing to make.

MR. SIMPSON: They are made in a die. I make each heart in about three blows of a steam hammer.

A MEMBER: What is the difference in price between the forging and casting?

MR. SIMPSON: The difference in price is $7.50 per pair in favor of the malleable casting.

MR. BECKER: I would like to ask Mr. Simpson whether he makes the tongue also of wrought iron?

MR. SIMPSON. Yes, sir. If it is necessary to have the one of wrought iron, it is necessary to have the other also.

The paper of the evening was next read by THOMAS P. ROBERTS, Civil Engineer, on

THE RAILROAD SITUATION IN PITTSBURGH, WITH REFERENCE TO ITS APPROACHES, ETC.

It is scarcely too much to say that there are few, if, indeed, any, cities in the United States which present for the consideration of engineers more interesting problems in railroad construction than

are afforded in and about Pittsburgh. By railroad construction it is to be understood that terminals and connections are here chiefly implied, the mere matter of approaching the city not being as yet a subject of extreme difficulty, though each year becoming more difficult and costly. There may be greater single projects presented in other cities, where a grand bridge, or submarine tunnel, or some such work once accomplished may revolutionize the system of freight and passenger traffic for the locality, as was done at St. Louis by Capt. Eads in his great tubular arch bridge, and as it is proposed to relieve New York of its insular position by bridging, or tunneling, the North River. In such instances, we can see at once, that if one bridge or tunnel, as the case may be, should, in the progress of time, be proved insufficient, they can be duplicated when the necessity for duplicating them arrives. But in Pittsburgh, crowded as she is between hills rising almost to the dignified altitude of mountains, on the narrow margins of rivers, every inch of which is now utilized by giant producers of freight which cannot be disturbed, it does almost appear that the limit of railroad development was about reached; that is to say, that we can make no further room for railroads without sacrificing interests of greater value than the "improved facilities," if we may so term them, would be to the community.

This is really a very important problem. It is true that it is taking time by the forelock to discuss it now, for there are many who believe that our transportation facilities, as they now exist, are ample, not only for the present, but for decades to come; but for one, the writer will not accede to this proposition. We are, I may say, unfortunately situated in one respect, and that is in being established on one of the great natural highways between the East and the West. So long as this natural highway trade, or through business, did not interfere with our own traffic, it was well and good, and we were proud to think that the commerce of Chicago, Cincinnati and St. Louis, separated as they were in the West, united their tributes at this gate city, as on a single cord, again to be spread apart to reach its destination at Baltimore, Philadelphia, Boston, or New York; but of late the notion has become prevalent—a notion, by the way, which was a long time in forming—that there is little advantage in having other people's

freight blockade our streets. In Pittsburgh we can count the coke cars destined for the Joliet, or the North Chicago rolling mills, and calculate just how the steel rail trade is flourishing in the West; and then we have the pleasure of inhaling the odors—the invigorating odors—of the beeves, sheep and pigs destined for the Eastern markets, without paying one cent for the privilege. In fact, the noise and bustle of freight trains, no matter whose property they convey, are now rightfully regarded as nuisances in all of our great cities; so much so, indeed, that millions of dollars in some places are spent to abate the evil, in the construction of "cut-offs," union, or connecting railroads outside the cities' limits. In the case of other cities, as beforesaid, there are seldom any great engineering difficulties in the way of obtaining relief from the annoyances of a through business by such means, but here the conformation of the country is such that no first class freight routes can, it is believed by some, be made to avoid the Pittsburgh gauntlet. If we look to the north of us we can discern no vision of hope as we gaze over the billowy hills, excepting, hull-down on the horizon, a little speck "no bigger than a man's hand" reads through the glass "Punxsutawney." Punxsutawney has a great East and West route concealed somewhere about its person, and may some day be a formidable cattle town, as Pittsburgh and Buffalo are now, and therefore Punxsutawney is a worthy objective point for railroad builders.

To the south of us lies even a more difficult region to pass through or circumvent—the celebrated Panhandle region. The account of surveys and railroad construction through this district is worthy of a special paper, but I will not here even attempt to outline it. It is a terrible region to begin with—right at our doors—and gets worse the farther south we go through it, and nowhere else are there the remains of so many ill-advised and now abandoned railroad grades as are here to be found.

I do not wish to say, however, that I regard it as impracticable to build railroads across this district, from the Monongahela to the Ohio River. I know from personal knowledge that by way of Peter's Creek and its branches a comparatively easy route exists to connect the Monongahela River with the Ohio by means of Chartiers Creek — but this is by no means traversing the Panhandle district.

Col. Thomas A. Scott, late President of the Pennsylvania Ra road, once remarked that Pittsburgh was the most difficult city the interior to pass through with a railroad, that is, of course, any other company than the one he represented. The Pennsy vania system through Pittsburgh, though not originally intend to be a through line, has, through the force of circumstances a wise administration from the very start of railroading here, unit its western approaches with its grand roomy eastern outlet on plan which cannot help but command our admiration. Unfo tunately there is, after such a first choice, but poor pickings f after-comers. It was, no doubt, with a full knowledge of t situation here that Scott made the oft-quoted remark above r peated. He might have further stated that, in addition to t difficulties of passage through the city, it was next to impossible t get around it.

It is curious to note how many streams, all available railroa outlets or approaches, converge on Pittsburgh. By reference t the map we will find these streams occupied by railroads, as fol lows, to wit:

1st. To the North—We have the valley of Pine Creek, throug which the Pittsburgh & Western Railroad grape-vines its way and little margin the Western leaves for another road to paralle it.

2d. The Northeast—The Allegheny River, its right bank occupied by the Western Pennsylvania, and its left bank by the Allegheny Valley Railroad.

3d. The East—Where we find Turtle Creek cut to pieces to make the Pennsylvania Railroad highway to the sea-board.

4th. The Southeast—Where we find the Youghiogheny enticing the B. & O. to the Chesapeake Bay and the National Capital, and, paralleling it on the opposite bank, the P., McK. & Y. Railroad, reaching after the Connellsville coke trade, and resting on its oars until it will shake hands with the Reading system at Harrisburg.

5th. The South—The Monongahela River valley, occupied by the Pittsburgh, Virginia & Charleston on the left, and the infant McKeesport & Belle Vernon on the right bank.

6th. Towards the Southwest—Street's Run, the B. & O. route to Wheeling and Cincinnati.

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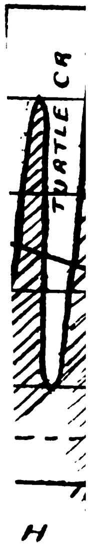

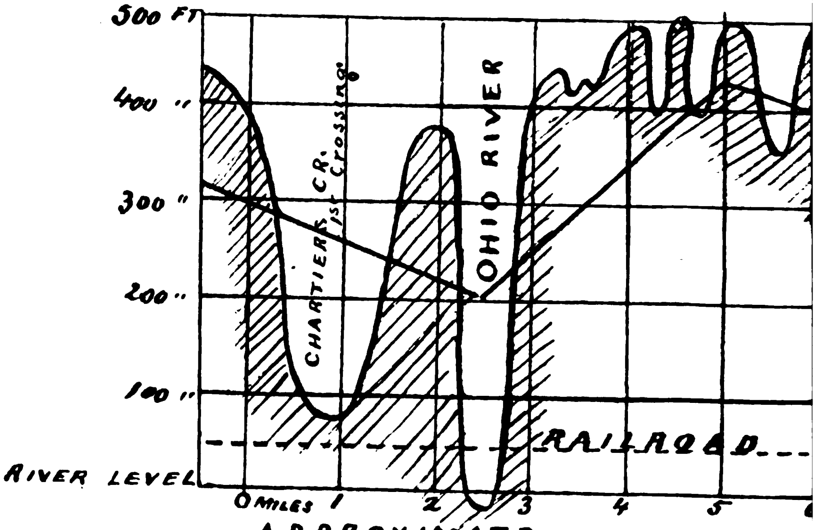

APPROXIMATE PROFILE (

7th. The West—Chartiers Creek, for some distance made use of by the Pittsburgh, Cincinnati & St. Louis (Panhandle) for Columbus and the West.

8th. The Northwest—The Ohio River outlet for Chicago, Cleveland, Detroit, etc.; the Pittsburgh & Lake Erie occupying its left bank, and the Pittsburgh, Fort Wayne & Chicago its right bank.

There are streams intermediate between those named, such as Saw Mill Run, Beck's Run, Girty's Run, Woods' Run, etc., on some of which local coal roads are operated, while all of them are practicable for railroads—requiring, however, tunnels near their sources to connect them with streams leading away from the city. The situation is a remarkable one, twelve or more water-courses pouring their floods directly towards Pittsburgh, and it is likely a situation perhaps without a parallel as a physical fact elsewhere in the country.

Upon the appended sketch I exhibit a circle having a diameter of eight miles, with Shadyside, the geographical center of Pittsburgh, for its center. Upon another sketch is the approximate profile of this circular line, drawn with horizontal scale, one-half inch equaling one mile; vertical scale, one inch equaling two hundred feet. It is reasonably correct, and shows a range in elevation between zero at river crossings, to upwards of five hundred feet above that datum at the summits of many of the divides. This profile, better than any language can do, serves to illustrate the topography of the peculiar region of which Pittsburgh is the center. The red line represents a projected railroad grade. A severe location, I will admit, and no doubt it is susceptible of improvement. The maximum grades of one hundred feet per mile were determined upon in order to lift the line as far as possible out of the ground and to save tunnel work. Two hundred feet elevation above the river was determined upon as the maximum crossing elevation. Yet it will be seen that even with these tremendous concessions the circular railroad will involve twenty-six tunnels, varying in length from a few hundred feet to one and three-fourth miles, with a total length of eleven and three-fourth miles of tunnel. In addition, we have one and one-half miles of river bridging, averaging two hundred feet in height.

It is simply impossible to go around the built up limits of Pittsburgh with an intercepting railroad, unless we make such road nearly a continuous tunnel, and then it meets at grade only a few of the railroads which enter the city.

WHAT IS THE NECESSITY FOR ENLARGING THE FACILITIES OF RAILROAD PASSAGE THROUGH PITTSBURGH?

The stockholders in any large concern which enjoys a monopoly in a given locality will assert themselves as able to attend to any possible increase of business. The argument is a sound one, viz.: that no more capital should be locked up in any industry than is absolutely necessary. What a saving it would be if the capital of all the banks of Pittsburgh was combined in one institution, managed by one president and one cashier? The investment in real estate and other non-productive items would be greatly curtailed, and much larger dividends could be paid. This is sound argument, but still there are so many obstinate, discontented people in this world that they will never see things in this way.

There is, I was once told by a highly accomplished member of the Pennsylvania State Geological Survey Corps, no necessity for building another great railroad through Pennsylvania so long as the Pennsylvania Railroad was not worked to its full capacity. Its ultimate capacity at the time the remark was made was not nearly reached, nor is it yet reached by any means. But this road was once a single track, and before business on it had reached its ultimate capacity the road was double tracked, and now it is in the process of being triple, and in some divisions quadrupled with tracks. Plainly that road is able to keep ahead of the growth of trade, or, at least, has done so thus far. And now arise a lot of obstinate people who say that when a road has business enough for two tracks there is room for another company to go into business. Pittsburgh has representatives of this class among some of her greatest capitalists, and no doubt they intend ultimately to have a new through road from this city to the East constructed.

At the rate of growth of Pittsburgh—and its freight business grows at a faster ratio than its population—the time will not be long until her facilities must be largely increased. Should natural gas fail us and we had to depend as before on coal fuel, the siding

and switching room about this city would be completely overwhelmed. Natural gas came to our relief for a time, and has given our transportation companies a breathing spell, but now the old coal tracks are about full of freight cars, so we need greater facilities if the gas is to last, and if it fails, we will require even greater facilities.

I have gotten thus far with my subject, and fear that I have involved it in difficulties from which it cannot be extricated—like the mechanic who riveted himself tight in his boiler and couldn't get out. The committee in giving me my subject only requested me to say something about the approaches to Pittsburgh as they exist, and I have done so as briefly as possible. How they can be improved or enlarged involves something more than mere description, such as I have been heretofore attempting. If attention were to be directed to a specified project of this kind, something to the point might be said, although I think our members will agree with me in the belief that no valuable engineering projects can be formulated without profound study; they do not come hap-hazard, and no engineer is likely to produce a treatise on the needs of Pittsburgh for improved railroad facilities unless spurred to effort by the actual necessity of a corporation which demands his services.

There are, however, some general considerations in connection with the subject to which I desire to advert in closing this paper, which, if I am not mistaken, may help to solve the problems as they successively arise in the future.

OUR RIVER BANKS.

I have for years entertained the belief that our river banks could be utilized for railroad purposes to a much greater extent than they are yet or have been proposed to be so used.

I do not believe that the fillings about some of the mills, etc., so much complained of, threaten us in the least by adding to the height of our great river floods. As this matter is important, and knowing full well that my dictum on the subject may be called in question, I will take this occasion—seeing that it is relevant to the subject handed me by the Programme Committee, to state some of the reasons which influence my judgment.

It is important to understand the natural minimum width required in a river to pass its flood waters. As a rule, on our western soft bottom rivers we can derive the safe minimum width from a measurement of its least width on any node, *i. e.*, any division between large tributaries, provided the thalweg or low water slope is the same throughout the division, and that there are no very severe bends in one part absent in another to be chosen for comparison. Another thing also to be had, if possible, is the record of widths, also flood heights, as they existed prior to settlement in this country.

We may depend upon it that water which goes through a two-foot square box, and then expands into a wide, shallow brook, can be confined again and made to pass through another two-foot box. Not all engineers are, however, aware of this fact. I have traveled over numerous railroads where, in crossing and recrossing the same water-course, the length of bridging and consequent number of piers has astonishingly varied. The bridges were simply adapted to the whims of a silly creek or river, as the case might be. I have not the slightest doubt but that many thousands of dollars which have been expended on such bridges might have been saved had an intelligent consideration been given to the points I here refer to.

No more water passes down our rivers now than in the period of the first settlement of this region by white men. I will make a slight amendment to this statement, for it is true that the recent flood of July on the Monongahela River was, in the upper part of its course, from two to three feet higher than the flood of 1832, the highest known heretofore; but it was not so at Pittsburgh. The rivers here are, as a rule, wider than they were before the days of active steamboating, and steamboating, I am quite convinced, was the chief cause of this widening process in both the Allegheny and Monongahela, and, I may say, the Ohio River as well. The waves from the wheel washed the banks down, and they are doing it yet.

A considerable portion of the Monongahela River, between this city and the mouth of the Youghiogheny River, fifteen miles up, is three hundred feet wider than it was when Dr. Howard made his survey of it in 1833. The effect of floods in passing these

widened stretches is simply a reduction in the velocity of the current, and the consequent deposition of more or less sand and gravel in the channel.

It would be perfectly safe to fill out, therefore, three hundred feet at least in such places, in fact, it would benefit navigation, for the material now in process of making shoals would be taken up and removed from the river; but I think it can be shown that even more than three hundred feet width can be added to the river banks in some places without increasing the height of floods—between this city and McKeesport.

Experience has demonstrated that dams made fifteen feet high across this river, where it is nearly one thousand feet wide, have not obstructed the discharge to an extent sufficient to notably increase the height of great floods. Their effect is, however, always observed in an acceleration of the velocity of the current in the neighborhood of the dam. Such a dam between banks, say thirty feet high, actually takes up half the section of the river—leaving, instead of, say thirty thousand square feet, fifteen thousand square feet of water-way for the passage of thirty-foot floods. Now, the same fifteen thousand square feet, if, instead of being put in as an obstruction in the form of a dam, were divided in two parts of seven thousand five hundred feet each, would permit of the banks being built out from each side two hundred and fifty feet, leaving the water-way five hundred, instead of one thousand feet wide. This would undoubtedly produce a current too violent for steamboats to navigate, but would not materially increase the height of floods. The scouring effect on the river-bed would eventually proceed to such a depth that in turn the section of fifteen thousand square feet would approximate the original thirty thousand feet, and the velocity of the current would be slackened proportionately.

I state this merely as a generalization of theory, which is, however, supported by facts; but I am not rash enough to assert that this is a safe rule, for, indeed, there are narrow places in the Monongahela—made so artificially—at certain points, beyond which the narrowing of the river should not be permitted to proceed.

Under nearly all the thirty-two bridges spanning the Allegheny River in 1879, I found, as a rule, deeper water than the adjacent

portions above and below those structures, and some measurements I took at the time convinced me that, as a rule, the scour under bridges could be measured by the number of cubic yards contained in the masonry of the piers, and the rip-rap around them. In other words, nature had restored the section to the river the portion stolen by the obstructing piers and rip-rap.

The fear of increasing the height of floods in our rivers by constructing a wide stable railroad embankment along at least one shore of our rivers has never alarmed me, but in offering this suggestion as a method of relieving the railroad situation, I cannot close my eyes to the fact that the rights of navigation must be scrupulously guarded. No harm must be done the rivers. The Ohio River has extended the name and influence of Pittsburgh farther to the South, the West, and the North than even the greatest of our roads has reached with its longest branches. Four thousand miles away from this city I have stepped off a Pittsburgh steamer, amidst the Rocky Mountains; again, I have met them in Minnesota, nearly five hundred miles northwest of Chicago, while their names are "household words" along the Mississippi and its branches, to the Gulf States. The freight and passenger boats are now moving on the Western waters with less and less frequency each year—for railroads have found it worth their while to reduce their rates so as to more than compete with them, but the General Government will improve the rivers, notwithstanding the decline in river transportation, since the argument is made that while they remain navigable they are a menace to exorbitant rail rates. Pittsburgh differs from other Western cities in having a large coal trade on her rivers, with which railroads will probably never be able to compete, and this trade our railroads should really foster, for without the aid of cheap coal in the West the business from the freight centers in that region would not grow as it is now doing.

I can see no good reason why six tracks at the least width, and many more tracks on extended reaches, may not be carried down the left bank of the Monongahela through our city, thence down the Ohio, with an equal number down the right bank of the Allegheny, and on down the Ohio. We have as an obstacle to such a proposed scheme the river lines, as established by law. The Com-

missioners who established those lines were good men, but I do not think the engineers who made the survey gave the question the thorough investigation its importance seems in these days to demand.

There are many points of interest which have occurred to me in connection with the subject of this paper which I have felt compelled to neglect. Amongst these was the proposed connection of the Panhandle with the Fort Wayne Railroad by means of a grand bridge across the Ohio River at Brunot's Island. It was my intention to have elicited some information regarding this project from Mr. Becker, but on further consideration I thought it would be better to hear from that gentleman himself, if he had any communication to make to the Society.

In the way of history I had thought, also, of referring to the bridge and tunnel work about Pittsburgh, of which we have a variety, and some of which afford notable examples of the highest skill in railroad engineering. For instance, the Fort Wayne bridge across the Allegheny River—when will it ever wear out? the Panhandle bridge—thrice rebuilt without stopping trains; the P., McK. & Y. Railroad bridge at Homestead, with its long approaches; the B. & O. Street's Run bridge; the Junction, with its elevated railroad attachment, to say nothing of the many minor bridges and trestles about the city. In tunnels, the feat of double-tracking the Cork's Run tunnel, where I believe it was shown that it is cheaper to build a new double track tunnel than to attempt an enlargement of an old one, on a busy road, without stopping trains.

The difficulties of the P., McK. & Y. Railroad in tunneling at a shallow depth, under a great rolling mill, was worthy of note. So also the fine tunnel of the Junction Railroad, under the entire length of Neville street, with its constructing shaft sunk off the line of its center. The great retaining wall of the Panhandle Railroad, below Smithfield street, and inquiry as to the advisability of tunneling a parallel route part of the way between Smithfield street and Saw Mill Run. Next, the B. & O.'s approach to the city, and the advisability of facing up a part of Boyd's Hill with a slope wall, and removing a portion of the threatening overhanging weight of rock; the Pennsylvania's new stone bridges;

the elevated, or tunnel, railroads to relieve the street crossings in Pittsburgh and Allegheny; the pile work along our rivers; conflict between the Junction and Allegheny Valley Railroad. These are a few of the points which suggested themselves as relevant to the subject we have for discussion to-night. It strikes me, however, that their enumeration alone is sufficient for one night's entertainment.

THE DISCUSSION OF MR. ROBERTS' PAPER.

MR. ROBERTS: I admit that I could not see any other way to bring railroads into Pittsburgh than down the river banks. They are doing that, but not in a very wise manner. I think the rights and privileges connected with such matters should be very carefully guarded. But I do think that in looking into this matter with reference to the future, that will be the use our river banks will be most largely made of. I speak of the sides opposite the business side of Pittsburgh on both rivers. I do not know where else any new railroads coming through Pittsburgh can be put.

MR. WILKINS: I would like to make a remark on that question. The Monongahela Connecting Railroad runs along the river bank for about 240 feet with a single track, and Moorhead-McCleane Company claim they are damaged to the amount of $50,000. If six tracks were put there it would be a very expensive proceeding.

MR. ROBERTS: The tracks the gentleman refers to are on private property, but there may be room for more tracks outside the "high water lines," which is public property. Moreover, as I said in my paper, the South Side, and not the one referred to by the gentleman, is the one on which a new road to pass through Pittsburgh would naturally look for a right of way.

MR. WILKINS: I would just make this statement, that yesterday the first train on the extension of the Monongahela Connecting Railroad, from Jones & Laughlins down to Moorhead's, ran over the trestle. This gives the mills along its line connection with the B. & O., and on the South Side through the McKeesport line with the P. & L. E.

MR. BECKER: I believe that the supply is generally about regulated by the demand. When the time comes for Pittsburgh to have additional facilities in the way of railroads I do not think

there will be a particle of trouble in supplying them as fast as they are needed. Of course in taking care of local traffic it will always be necessary to get into the business part of the city, and with the rapid development of all industries in this vicinity we can readily foresee that there will be a time coming when the local traffic alone will be so large that some means will have to be found to divert the through traffic. The growth of our Western States and Territories, and the transportation necessities for their products, are now increasing at a much greater ratio than our home traffic, so that some day in the future, I do not know how soon, there will be a necessity arising to carry the through traffic around the city in some way, instead of passing through it, as the case is now, and it is principally with that view that the project which Mr. Roberts has mentioned is now in contemplation, which is simply a line connecting the Panhandle Railroad system with the Fort Wayne, in order to carry the coal traffic from the lines reached by the Panhandle R. R. across the Ohio River at Brunot's Island, and deliver it to the Fort Wayne Railroad in the lower part of Manchester, in the neighborhood of Wood's Run, and from there reach the lake ports without having all to pass through this city. The Panhandle Railroad has really no inlet excepting the Try street tunnel, which is a very narrow gorge for the traffic of such a line.

Similar projects to this one will certainly be adopted and carried out whenever the necessity arises in the through lines. I do not look with any great alarm upon the future, and I think we will be able to travel by railroad in the future as conveniently as we can to-day, and what we may have to ship will be properly taken care of without borrowing room from the Ohio River.

Further discussion was postponed until the next meeting.

ARTHUR KIRK offered the following report, which was adopted by a rising vote, on the death of our late member,

WILLIAM MILLER.

Mr. President and Fellow-members of the Western Pennsylvania Engineers' Society:

The mournful duty has been assigned to me of writing a memorial of our highly-respected fellow-member, William Miller,

who, after a three months' sickness, departed this life on September 21st, 1888, mourned and regretted by all who knew him.

Mr. Miller was born at Duntocher, near Glasgow, Scotland, July 21st, 1820. At the age of fifteen he was apprenticed to the trade of a hammerman, which apprenticeship he faithfully served, and became one of the most expert hammermen of his day. At the age of twenty five he married Jean Stout, a native of Iona, and, in 1849, he emigrated to the United States and became connected with West Point Foundry at Cold Spring, N. Y., on the Hudson river. In 1855 he returned to Scotland, and was employed in the large forge works of the Denny's, near Dumbarton, where many of the celebrated Clyde steamers were built.

But, having once resided six years in the United States, he could not content himself in Scotland, and, in 1858, he again, with his family, now consisting of wife and six children, returned to the United States and settled in Pittsburgh, and soon became interested in the West Point Forge on Water street, in company with J. P. Haigh, and, in 1860, this became the Duquesne Forge, with Mr. Miller president, and he became sole proprietor in 1864.

During the late war many very important forgings were made under the personal superintendence of Mr. Miller. He took great pride in making extra good work, and was always successful in giving entire satisfaction.

A great help to this was the kindly feelings which always existed between Mr. Miller and his workmen.

A strike was never known at his works, and, although his funeral was to be private, his workmen sent the family a request that they might be permitted to walk and follow him to the grave, saying: "It will be our last chance to do anything for him." The request was granted, and over one hundred workmen marched two and two about two miles to the grave and back again in a body, wearing black badges with "We Mourn our Loss" in gilt letters.

In 1882 the business was still further enlarged by the building of still larger works at Rankins' Station, seven miles up the B. & O. R. R. and fronting on the Monongahela river. In these works he placed some of the largest and best tools for his work ever made in any country. Among these may be mentioned, that he could

make forgings of any shape and of any weight up to forty tons, and had a turning lathe that could swing and finish a shaft forty feet long and weighing forty tons, and a slotting machine for finishing forgings which could take a cut a quarter inch deep, three inches wide and fifty-four inches long.

He was mainly instrumental in having the U. S. Government adopt a built-up, double-throw crank shaft, which is now used on all large work, instead of one cut from a solid forging.

He was a life-long member of the United Presbyterian Church, and a true Scotchman, noted for his sterling integrity and public spirit. He was one of the original members of our Society, and a member of the Mechanical Engineers' Society of the United States.

It was immediately after returning from a meeting of that society at Nashville that he took sick, which resulted in death. He was president for two years of the Pittsburgh Exposition Society, and during that time the society paid off nearly fifty thousand dollars of debt. He was director in the M. & M. Bank for five years, director in the Union Storage Co., also a director in the Chartiers Railroad and president of the Miller Forge Co. at the time of his death.

Yet in the midst of all this usefulness he was called away, and by his death the warning is again given to all of us: Be ye also ready, for in such an hour as ye know not death may come to any one of us.

The following report was made by the Committee on the Death of

D. M. Smith.

We are again called on to pay the last tribute of respect to a departed member, to place his name on the record of our Society's dead, and give a brief synopsis of his career.

David M. Smith was born in Allegheny City, April 12, 1836, and died in the same city May 24, 1888. Possessed of a fair English education, acquired mainly in the First Ward Public School, in Allegheny City, he, at an early age (about the year 1851), commenced his business career in the employ of his father and brother, who were engaged in mining and shipping coal to the Cincinnati and Southern markets. After the death of his father, in February,

and as it was thought that a little talk on what I saw would be of interest, I shall be pleased to give it to you to-night, but off-hand, as I can not read a paper. I always lose my place.

When Prof. Langley, Prof. Simon Newcomb and Prof. Young sent me letters of introduction to foreign scientific workers, and particularly to those engaged in scientific work, they told me that I would be received very kindly by every man interested in science, but that I would not be received so kindly by those interested in the manufacture of scientific instruments. The probability was that I would be allowed to go to the door, but "thus far should I go and no farther."

Of course, I felt disappointed when I learned this. I had heard from a great many who had visited European manufacturers that there was a difficulty in getting into the shops, and particularly into optical works, but I will say to-night, and I say it with the greatest of pleasure, that there was not a single workshop I visited whose doors were not opened wide to me. I do not say it was because they knew anything of the work I had done (that would be egotism), but it seemed to me that there was a spirit of kindness among scientific workers in the old world that agreeably disappointed me. I found them very much like Americans, at least in their generous treatment.

You all know something of Alvan Clarke. You know the work he has done. He has finished his life work here and can peacefully rest. When I first visited him seven or eight years ago, as soon as the good old man found I had any interest at all in astronomical work, he received me with the very greatest kindness, and at once took me out to *see his chickens*. After he showed me his chickens he showed me a portrait he had painted of his father and then told me a story of how near he came to locating in Pittsburgh in 1841. He said that it was the merest chance that prevented him from coming here, and added that he was glad he did not come. I always found him a cheerful, genuine, and upright man; a man you could not help loving the very minute you saw him. At his place you were made welcome at once. I remember on one occasion, before being up in that sort of work, he asked me to go and test a big prism (4 in. aperture) he was making at the time. I went out and tested the glass. Of course I did not know much about

it, but I remember the talk I had with him, and whenever I went there he always received me with kindness, and when, in 1886, I was on a visit to Boston, with Dr. Herron, of Allegheny, and he learned we were there, he gave us an invitation to come and look into the object glass of the great Lick telescope. At the time Prof. Simon Newcomb was there testing it.

Alvan Clarke was an humble, devoted follower of his chosen pursuit. He was so because he loved it, and there was no selfishness about him at all. I am glad to say that I found some people of that sort when abroad.

The first place I visited was the great optical works of Chance. I got there about dinner time, but I excused myself and told the younger Mr. Chance that if he was ready to go to dinner not to stop for me; we would wait until he came back. "Well," said he, "that is all right. I will go, and see you after dinner." He fixed everything nicely for us in the office. We had plenty of papers and books to read and were getting interested, when in the course of twenty minutes a *very nice dinner* was sent to us, served in the office in capital style. After dinner we spent about two hours testing a number of the larger optical glasses the firm had made. One of the glasses he showed me, and which I was permitted to test, was a great 28 in. glass he had just finished, and several lenses for the observatory at Greenwich. You have perhaps all heard about the work of Chance Brothers. They are largely engaged in the manufacture of light-houses and I presume they are the largest makers of light-houses in the world. The lenses and prisms used for this class of work interested me very much. They showed me all around their works, their method of polishing and everything about it. We do not make light-houses, but at the same time I was interested in all they did. Their methods are crude if compared to the optical methods of the present day, but we all know that light-house lenses do not need such accurateness as those of the telescope, spectroscope, or other instruments of precision. I was much pleased to see their method of work and method of testing. I was also more pleased to have their opinion about their optical glasses. They wanted me to look for any defects that might remain in the discs. I located one or two small stria they had not seen. I have had a great deal of experience in detecting errors, but fortunately

those I found were in the surface and not in the interior and could be easily ground out. If I have time, I will try to tell you something about optical glasses before I close.

The first astronomical instrument works I visited in England was the great works of George Calver, of Chelmsford. Perhaps Mr. Calver has done the greatest amount of work on silvered glass reflecting telescopes in Great Britain. Foucault, you may know, first developed this work, then several of the German opticians and then the English opticians took hold of it.

I had anticipated the pleasure of going to see the works of Mr. Calver, because he made the great 37 in. telescope for Mr. Ainslie Common, photographs of which I brought and showed to the Engineers' Society some time since, as also the photographs of the nebula in Orion made by the same, only equaled by those taken by Henry Brothers, of the Paris Observatory.

My anticipations were very large. I went to his house; was received very kindly. After taking dinner with Mr. Calver, I began to look around for the optical shop, but I did not find any. We started for a walk and I thought we were going to the optical shop, as he knew that was my objective point. He led me out to a field and showed me his horse, something like good old Alvan Clarke with his chickens, and after about half an hour I began to suspect that the man did not propose to show me anything. I was dodging around the question and put out some pretty strong hints.

When we returned to the house, I was led into a little barn, about 12 feet square, and there was his *optical* shop, all the machines piled up with an accumulation of dirt of two or three years. Two or three machines worked by turning a crank. I tell you I saw all of that optical shop in five minutes I wanted to see.

While he was a genial man, I must say that his optical works were not to my taste at all. It is very curious how some people can do good work, and yet work in the dirt up to their eyes.

After leaving Calvers I went to Cambridge, spending a delightful time, where I was permitted to see and take apart the telescope made by Sir Isaac Newton. I examined the mirror, measured its constants, etc. Thence I went to the Royal Institute in London, and I should like to have had Prof. Langley and Prof. Frost along

with me, because they had something there very interesting, which I have not time now to describe.

I did not go to Greenwich, because I did not think they had anything very new, that is, anything of recent date, excepting what Sir Howard Grubb was doing for them, and which I saw at his works. In London I visited Mr. Hilger's works and found some very beautiful spectroscopes being constructed, and I also noticed some beautiful prisms. Some made of Iceland Spar were the largest and best I have seen anywhere.

I hurried on over to Paris and there met with the warmest reception from the Director of the Paris Observatory. I there met an English lady who acted as interpreter. The director could talk English a little and I could talk French very badly, but we managed to get along splendidly. I was permitted there to examine all of the works of Foucault, the telescopes he had made, including the silvered glass telescopes and quite a number of other astronomical and physical instruments.

I was particularly interested in some of the glasses of the early astronomers. In the Museum I saw the glass that Cassini used when he discovered the double ring of Saturn. It is about 8 in. diameter, with something like 25 feet focus. It was made of plate glass, not more than 1-4 inch thick, with, of course, a very small curvature. I could see the stria in it at once by holding it up to the light. I have wondered more than ever, since I saw that glass, how such good work was done by the old astronomers.

I was introduced by the Secretary of the observatory to the Henry Brothers and by the Henry Brothers to Gautier, the greatest telescope manufacturer in France. He took the old shop of Eichens and is now doing I presume the best work in France, especially in the manufacture of the equatorial coude which is now taking a very prominent place in astronomical work in Europe, and I have no doubt will become an instrument more and more used every year. I did not expect to get into Gautier's shop, but to tell the truth I did not see any "shop" in the sense we use this word, except Gautiers, in all Europe, and while I can not say as much about them as I would like, I will say they are far behind us in mechanical appliances.

In the shops of Gautier the workmen looked more like the

workmen of one of our factories. They wore a loose gown fastened at the neck, with loose arm sleeves, coming down to a considerable distance below the knees, and of course when a man gets grease on his hands down it goes (by a gesture expressing the act of rubbing the grease on their gowns). I suppose they wore them for a week or two. They did not look as if they had just come out of a laundry, but at the same time the work they did commends itself to any man who has any knowledge of good workmanship.

They are now constructing an instrument in France called "the equatorial coude" already mentioned. Astronomers and instrument makers are every day endeavoring to make the work of the astronomer less and less difficult. Every man who has had anything to do with measurements of precision knows that the less he has to consider, outside of the actual work in hand, the more perfect his work will be. In other words, if a man has to lie in an uncomfortable position to make measurements with the micrometer, the natural tendency of the body to get into an easier position will take some consideration of mind, or the mind will be doing something towards the fixing of the body in a comfortable position, thus lessening the "energy" he can command for the work in hand.

The "equatorial coude" is an instrument by which a man can make all his astronomical observations, seated very comfortably in his room, smoking his cigar if he pleased, and have everything comfortable around him, and not have to go into the cold drafts of the observatory as we generally have to do. He can make his measurements from the inside and make all his observations, seated at his telescope, without having to go outside at all. Gautier is now constructing some very large instruments of this kind. 23 inches in diameter is the largest they are now undertaking to construct.

I have drawn a mere outline of the general idea of this instrument, which you will see here (illustrating from the black-board). The telescope itself, or rather what you might call the tube of the telescope, is set to the polar position of the observatory, and thus a line drawn through the axis of the telescope would point to the north pole of the heavens. At the bottom of the telescope the

objective is placed, just as it would be if we were to turn it up the other way. Below it is placed a mirror, set at an angle of 45 degrees. On one side is placed a secondary mirror which can be rotated in any direction, and by the movement of this (illustrating) around its axis, or this (illustrating) any star, except probably within two or three degrees of the pole, can be brought into view of the telescope. Now, as the circles may all be placed at the observing end of the telescope, in a comfortable house, with the lower part of the tube outside, it can readily be seen that the right ascension circle can be put here (illustrating), and that at some point the circle which moves the mirror to set it in the north and south direction, can also be brought to the upper end. The micrometer can be placed here (illustrating) and the whole telescope, which is counterpoised by the weight here, can be swung freely on its axis.

One thing I noticed as very peculiar in the "equatorial coude" was that instead of having the instrument counterpoised as we would here in America by some device that would balance the whole mass of weight, for instance, on steel balls, the device employed was very simple—only a conical pivot so far as I could see—but it seemed to move with great ease. I made several observations, and I am pleased to say that notwithstanding the adverse opinions that have been made on the connection of two mirrors with the object glass, that the definition of the stars was very excellent indeed. As we have two reflecting surfaces here, and you will remember that any error of reflection is always doubled, so if we have two mirrors it will be quadrupled.

However, Prof. Langley and Alvan Clarke both told me they had made observations with this telescope, the first one constructed, and they both pronounced the definition of stars very excellent indeed. I found on observing with an eye-piece of quite considerable power, that the definition left nothing to be desired. I can assure you that it was very comfortable to sit in an arm chair inside of a room making your observations, while that part of the apparatus which must necessarily be nearly of the same temperature as the atmosphere outside remained uncovered, except when the instrument was not in use. There was no occasion at all to go outside of the building for setting the telescope upon stars and other

celestial bodies. This telescope was about 10 in. clear aperture, the mirrors somewhat larger, and the work was very excellent. As I have remarked, they are now constructing instruments of this kind up to 23 in. diameter. You may know how accurate these surfaces must be when magnification of from 200 to probably 1,000 is required, and an error that would occur in these mirrors or in the objective would be multiplied by the magnifying power of the eyepiece itself, which is really the microscope of the telescope.

After visiting the works of Gautier, seeing the way they did their work with very good appliances, I visited the works of Henry Brothers. Let me say here that with the exception of Sir Howard Grubb's I do not know of any place in Europe where they are doing any optical work by machinery. The works in Paris, and at several other places where they do a great deal of work that comes to America, you will find the workman standing turning a crank with one hand and with the other working on his lens. And they work from early morning until late at night, grinding away, while the Yankee would be found with a machine doing it, the machine being obedient to his will. I was really much interested in their delicacy of touch. I suppose that the turning of that crank becomes automatic. They do not seem to know when they are turning the crank. The "brain" is all put into the other hand, the left hand, with which they manipulate the lens. That is the way they work lenses all over Europe, even quite large lenses for telescopes.

At Henry Brothers I *expected* to find something big. The work they have done is known wherever there is an observatory. They are noble workers. They love their work so much that they would not care whether a man came in with a crown on his head or without shoes on his feet, so he was interested in their work they would make him welcome.

All optical works seem to me to be small in Europe, excepting Gautier's and Sir Howard Grubb's shop. I found nearly everybody had their homes in the same place as the work shop. When I went into the Henry Brothers' shop I was taken down to a little house in the same yard with their dwelling, and in which the work has all been done which has made their name famous everywhere. The first thing I saw was a flat mirror, 40 in. diameter, 7 in. thick,

made of glass, polished and figured, and the error on any part of that surface was probably—under normal conditions—less than one one-hundred-thousandth of an inch. Think of a surface four feet square and each part so correct as that. A person can hardly imagine what accuracy is demanded in a surface that has to reflect the image of a star, then send it through an objective, then be magnified 400 or 500 times and still show no error. The support of a mirror like that is a serious matter. It is very difficult. The great 48 in. mirror which Martin made for the observatory at Paris has never yet been mounted successfully. It was figured good enough, but never mounted satisfactorily, but I believe Henry Brothers are undertaking to refigure it the same support that it will occupy when in the telescope tube.

I said a moment ago that one can hardly appreciate the accuracy with which a glass has to be figured so as to show no error. My assistant, Mr. McDowell, a couple of weeks ago thought he would make some experiments with his spherometer to see if he could determine the errors of a glass which showed them very plainly by the Foucault test, errors so palpable that the glass was worthless for an accurate optical instrument, and yet the error in that glass we could not possibly determine with a spherometer by which we could measure certainly to one eighty-thousandth and almost certainly to one one-hundred-thousandth of an inch. The error was there, but we could not determine it with the spherometer. So you may have some idea of the accuracy with which a piece of glass four feet in diameter must have to be worked in order to show no error in a star of, well, any magnitude, in a telescope when magnifying 200, 300, 400, 500 or 600 times, and yet the Henry Brothers certainly have made glasses of such excellence as that.

Their method of polishing is totally different from ours. They use *paper* altogether. The father of the Henry Brothers, 70 years of age, had done much of the work on that great mirror I speak of. The kind of paper they use was thought to be a secret. When Dr. Hastings went over to Paris to learn how to polish lenses, and how to carry out his great purpose of practically demonstrating his mathematical theory of an achromatic objective, so as to have the least chromatic error, he frequented the restaurants where the opticians mostly went to get their lunch or their dinner, and learning

who they were he occasionally put up a bottle of wine, which, as you know, is more common than water in Paris, until he got into the good graces of the opticians, and after a little while they invited him to the shops. He got to going there occasionally, trying his hand at polishing, until he picked up the methods and finally became quite an accomplished optician so far as *their* methods are concerned. He went back home and endeavored to work with their methods by *paper* polishing, but after two years' trial he wrote me it was a perfect failure for large or very accurate surfaces, and that it was impossible for him to produce an optical surface of precision with the paper polisher. The Henry Brothers work with a *glass* grinder. (In America we use iron or brass.) In properly grinding a lens the grinder is made exactly the same curvature as the polisher. Thin albumen paper is cemented over this glass grinder, which makes a slight difference in the curvature, but the glass will soon assimilate to that curve. Indeed, these French opticians were using the ordinary albumen paper that is used by photographers for their polishers. They simply dip the paper in warm water and lay it gently on the glass; press it on the lens, dry it over a bunsen burner, smooth the rougher places with a cuttle fish bone, then transfer it to the glass they are going to polish, rub it over two or three times, dust over some "putty powder," let it dry, and inside of fifteen minutes they had a perfect polisher for the 13 in. glasses they were making. And yet I believe that Americans have not yet succeeded with this matter. However, I brought some of the material over with me, for I believe in trying anything any one else succeeds with, for after all we may find that we don't know everything in this line.

These men being brought up to this work with paper polishers are producing results they alone seem able to produce, and perhaps if we were to undertake to work our accurate surfaces with the practice we have had we would succeed very indifferently, and it would probably take half a lifetime to catch up to where they have reached.

Probably most of you know that Alvan Clark, the man who has made the finest glasses in the world, did most of his final work with the hand and the finger. Finding, for instance, a little error in his glass, Alvan, instead of polishing out this error as others

would do, would run gently over it with the tip of his finger (illustrating on the board the process) until the error had been removed.

I have tried that process myself. After the rubbing the error looks larger, but you forget that the heat of your hand and the heat generated by the action of your finger has swelled it up, and many a time after work of this kind, on feeling dissatisfied with the appearance, I got up in the morning and found the glass all right, because the heat had let go; it had assimilated into the mass. Henry Brothers do something of a similar character with their paper polishers.

I was invited by Dr. Janssen, President of the Academy of Sciences of France, to visit the great observatory of Mendon, and of course accepted the invitation. Here I found three large observatories being constructed, one of which will be nearly the same size as the Lick Observatory, and is really being reconstructed from the Chateau of the first Napoleon. The view of Paris and its environments from this observatory is superb. In the great stables, once filled by the great Emperor's fine horses, Dr. Janssen is now conducting experiments in long iron tubes, on the spectrum of various gases under high pressures; in fact, oxygen gas has been compressed into these tubes, with quartz ends fitted into them, such as would represent all the oxygen in a vertical column of the earth's atmosphere through its entire depth.

A great reflecting telescope of one metre diameter and three metres focus, is being erected here for photographing faint objects, such as nebulae and comets. A 13 inch photographic refractor is also being put up. "Mendon Observatory" is a live place, I assure you.

It would be manifestly unjust to leave Paris without a brief note of my visit to the celebrated optical glass works of Mantois, the successor of Feil, who has made the largest and perhaps finest object glass discs in the world. I have already noted the works of Chance, of Birmingham, England, where vast quantities of *all kinds* of glass are made, but at Mantois works only optical and the finest qualities of glass are made. The works have been reconstructed by Mantois, who has so much improved on the old works that it is a delight to go into his rooms where every variety

of optical glass may be found—from the great disc of 30 or more inches diameter, to the smallest glass for the microscope maker. Each kind of glass has its own department. Its index of refraction is marked upon it, and its density, so that selections of the kind of glass desired can be made at once. Facilities are also afforded the optician to test the glasses by polarized light or by diffused light, and I had the pleasure of testing a number of large discs that were remarkably perfect. The method of the original discoverer, Pierre Guinand, is quite strictly carried out, though of course improvements have been made from time to time. The materials of the "batch" are very carefully selected, and after being thoroughly melted are stirred either with a clay or platinum stirrer, until the impurities are worked to the top. This process is repeated several times until it is evident the glass is as homogeneous as fire and stirring will make it. The furnace is then luted up and the mass allowed to cool slowly. On being taken out of the furnace the pot is broken off—the glass generally being found in large pieces. These pieces are examined for stria and density. And in some cases weeks of labor are expended in cutting into the imperfect places and grinding them away. They are then carefully melted down in clay moulds of the proper shape and size for the use intended, and in this process great care is necessary to secure perfect discs, for none of the cut away places must be allowed to fold over in being melted down or the glass disc would be ruined.

It is frequently necessary, in lumps that prove good except certain spots that cannot be ground out, that they are gradually *coaxed* up to the surface when the glass is in a condition to do so, *i. e.*, when in a plastic state in the mould. The imperfection is then cut off, and again great care is necessary that there shall be *no overlapping* of the edges of the subsiding glass. These processes have to be repeated many times in large discs, and Messrs. Chance told me that they frequently return a disc to the annealing oven after it had been polished and found imperfect in some manner. If the disc should crack it would be ruined, hence it must be brought up to the proper heat by a very gradual process, or the work of months would be destroyed in a moment. Then, too, the glass is apt to devitrify, or become translucent, if

the heat is prolonged beyond a certain limit. Indeed, the maker of a large disc of optical glass has very many serious environments that bar the way to perfect success. Optical glass and ordinary glass are totally different things.

I should like to tell you more about it, but must proceed. I did not visit the new works at Jena, where they are making the new "Abbe" glass, although it was my original purpose to do so.

But I cannot stay in Paris any longer, because if I do you will get tired of me. After visiting the Paris Observatory and inspecting all the instruments there, which were of very great interest, and other scientific institutions in Paris, where I saw instruments of 100 to 200 years ago, and getting all the information I could, I went over to Munich. There I saw a great many things that I did not care to bring home with me, and yet I found earnest workers there, men who were plodding along for their 50 cents per day up to perhaps one dollar, doing work that in this country they would in all probability get $3 or $4 for at least, and more than one of them would have been glad to come home with me if I had given them any inducement to do so. But I have found in my experience that earnest and honest as the workers are in the old country, particularly of Germany, when they come here they are not able to follow out our methods without at least a year's practice.

I remember at one time being in great need of some one to help me. A German from the celebrated works of Repsold came along and told me he had been working on instruments of precision all his lifetime. I thought that this was the very man I wanted. I hired him at once. He went to work and the good fellow worked about eight weeks. In the eight weeks I think I paid him something like $125, and I got $35 for the work he did, and yet he worked as hard as he could all the time. But he had been so used to working with foot lathes and the hand tools of the shops of Germany, that when he stood with the slide rest screwed up, getting along very nicely, he was still afraid it was going too far or too fast and his *foot* would be going all the time. That foot kept going all the time he was with me. It had been an education of his foot for probably 30 or 40 years and he would never finish a piece of work by the slide rest without going over it two or three times and

putting on the finishing touches by hand. He worked harder than any man in my shop, but at last he came to me and said, "I cannot do justice to your work." He drifted away to a microscope works in Chicago. A week or more since he came to visit me, and told me he was learning a little now.

I visited the works of Steinheil. Anything I asked them they were glad enough to answer, and so were Ertel & Sons. Mr. Ertel said to me that he would rather work for an American than any other person on the face of the earth. Said he, "When I make an instrument for my own country I have to write a hundred letters and then have to wait, I don't know how long, for my pay. But when I work for an American he sends me but one letter, tells me what he wants. I do the work, send him the same and he sends me the check." He has a very good impression of American people.

Then I visited the Repsolds at Hamburg. They have the reputation of making the finest divided circles, such as you will see here to-night, of any firm in the world, and I supposed that their dividing engine was locked in their "sanctum sanctorum," and it would be impossible for me to see it; but it was one of the first things they showed me, and they showed me everything about it I desired to see. It was covered with bright tin in order to reflect as much of the heat of the body as possible, so that the machine should remain at a normal temperature. Every single line was set by the person doing the dividing from the circle, which was originally commenced by the grandfather of the present Repsolds, and finished by the father, and is now in use as probably the finest original dividing engine in Europe. At one time they set the circle by not less than five microscopes, in order to eliminate the errors of eccentricity and errors of division.

The observer sits here (illustrating) looking down on the line that has been drawn on the original instrument, pulls a little lever that makes the mark and then rotates it to another line, makes another mark and so one. I was told that it has taken as much as three months to divide some of the larger circles of the meridian instruments; also that it is only under certain conditions of temperature they can do the best work. I was informed by the Messrs Stackpole Bros., who have a very accurate dividing engine, that

in making the original divisions on their dividing engine 90 divisions were made in one fine night, and that four months' time was consumed in making as many more. I think they worked nearly two years on the original graduation of their first circle. The circle the Repsolds use is about 48 inches diameter, and I presume the circles divided by the Repsolds can be considered as the most perfect now made.

The Messrs. Repsold make a specialty of one class of instruments, but I think you will be somewhat interested in a brief description of some of their work; in their driving clock, for instance. Since the advent of photography in astronomical science the great desideratum has been to drive the telescope so that it would not deviate from the exact position in which it was directed. Now, let us suppose here (illustrating) that we have two cross lines, and let us suppose that we have a star bisected in front of them. Now, as that star must be exposed in some cases for at least two hours (in the case of some photographs taken by the Henry Brothers four hours exposure has been necessary) you can readily see that the slightest movement of the telescope itself varying from that of the motion of the earth will vitiate the worth of the photograph. Therefore all the photographs that have been taken by Henry Brothers have been taken by the use of two telescopes, one placed on top of the other, and the secondary telescope must be very large. It must be able to give as much magnification as it is possible to have in order that they can see the slightest deviation in the movement of the clock. They observe with the secondary telescope, while the other one is sending its image on the sensitive plate, and hence any error in the motion of the driving clock can instantly be detected and corrected by special appliances, which gives an independent motion to that given by the clock. The observer may have to sit at the eye-piece for four mortal hours. He must watch the star; it must not move the half diameter of itself, or it would superimpose on the plates an eliptical image, or a number of images might be shown where but one star existed.

As the photographs thus taken are preserved, and will be compared with pictures taken later, say a thousand years hence, you will see that it is very essential that the photographs shall be perfect.

You know that the siderial clock ought to keep accurate time, and it does so for four, five or six hours, so much so that if it were driving the telescope there would be no danger of the star getting off, but it is impossible to drive so heavy an instrument directly from a siderial clock. It is possible, however, to *control* the motion of the driving clock by the siderial clock. A wheel is placed on some part of the driving clock that we will say has 60 teeth. Now let this (illustrating) be the magnet that is connected with the pendulum of the siderial clock. The armature will move once for every beat of the pendulum, and will drop this catch between pins on the 60-tooth wheel of the driving clock, thus governing its motion quite accurately. As no regulator has yet been found of rotary pendulums that will give an absolutely regular motion, the motion of the clock itself is always made a little faster than it ought to go, hence this little catch here comes down and retards it at the proper time.

Sir Howard Grubb devised another plan, which I show you here, not very well, but will give you an idea. Instead of having the pin drop down and stop the motion suddenly, he places on the side two differential gears, slow and fast, and he connects them with his pendulum, and this little hook here dropping down into the gears of the differential, make the motion slower or faster, but not check it up suddenly. The differential gear can be made to give a little faster or a little slower motion just as you like, or better, just as the siderial clock demands. Sir Howard Grubb has thus overcome the errors of the driving clock in a very great measure.

Another beautiful thing he has devised is, that instead of having two strings to move the telescope in declination, he has a simple electrical device which the observer can put in his pocket. To it he attaches a differential gear and holds it back or accelerates it by a magnet, as in the regulator.

I will now describe what I think is a great advancement in driving clocks. Curious to say while it is supposed to have been discovered and made by the Repsolds, Mr. Repsold told me that he himself learned afterwards that a Yankee in Boston had discovered it and used it twenty years before, to regulate a Morse telegraphic instrument.

Let this axis (illustrating) be the axis of some fast moving part

of the train of the clock; it don't matter what part of the clock you take it from. Suppose it is revolving at the rate of 300 to 400 per minute. The driving apparatus may be back further. I have here another view of this. Here is a little slotted crank, which is curved somewhat. Its center is here and the crank moves in this direction. This rod is fastened solid to the base of the telescope pedestal and this upper end enters the slotted crank. A heavy cylindrical weight is secured by a milled head screw at the proper place on the rod, found by trial. It does look curious to see the rod spinning around, and I presume in time it will twist off at the bottom, but as it is steel it will be a very easy matter to replace it. You see it requires no intricate work. The principle is that the centrifugal energy of the ball on the rod is exactly controlled and regulated by the elasticity of the steel rod. This clock can be built for one-half the cost of the present form of clocks, and it is another evidence that even in the most abstruse scientific work the simple things are the best after all.

Another piece of work of the Repsolds and for which they have a world-wide reputation, is their heliometer. You may appreciate some of the difficulties of making this instrument when I tell you that I believe no one else has ever undertaken to construct it but the Repsolds.

I do not know whether you understand enough about optical science to know that one-half of an object glass of any telescope will give just as perfect an image as the whole of it, or if you cut the object glass in two, that the object glass as a whole will give a perfect image, and each separate half will also give a perfect image. Repsolds were just finishing a fine heliometer when I was there, and a beautiful instrument it is, I assure you. They told me the object glass had been made by Merz of Munich and had been cut in two, if I remember correctly, with a loss of only about one sixty-fourth of an inch of the objective, and was so perfect that no work had to be done on it afterwards. Of course it would add greatly to the cost of the objective after it was practically finished, for it has to be cut in two after it has been corrected and centered. So you may know some of the difficulties in constructing a lens of this kind. This instrument is used for measurements of celestial bodies—by double displacement—as you may infer from what I have said of

the object glass, the visual observations of which can be made very exact, and the amount of displacement of the two halves of the objective accurately measured.

I had a delightful time at what is called the Seewarte, in Hamburg, where they are doing a vast amount of work for the benefit of seamen. Dr. Neumayer probably stands at the head of that work in the world. He is at the head of the South Polar expedition, to be sent out for meteorological studies of that almost unknown region. He showed me many things of interest about the great observatory. They were making there, daily, charts of all voyages, information concerning which is brought to them by sailors from different parts of the world. The chart books are given to those who care to take an interest in it and they record everything that is of interest or value on their voyages. When they come back the observers at the Seewarte take the data they have brought with them and chart it out. I think they have ten to twenty lithographers in the observatory. Everything is lithographed. New lithographic stones are made every day. These lithographic maps are printed in a beautiful and substantial manner, and at the end of three years all the data relative to certain voyages is collected relating to storms, ocean currents, temperatures, soundings, &c., in that particular part of the ocean, and then whenever any one desires to refer to these data they are found very complete. The captain of a vessel wanting to take a voyage on any sea unknown to him has all these reference charts open to him, and he can at once tell what the currents may be and what the temperature is of the air and sea for every certain season, and indeed everything possible to know from the carefully prepared records.

I saw there Sir William Thompson's method of deep sea sounding, which is a very simple device, indeed. Let us say there is a tube of certain length. It is closed at the upper end. I have forgotten now what solution, but there is a solution run into the tube, which puts a thin coating around inside of it. The tube is put down into the sea, weighted to carry it down, and the deeper it goes the greater the pressure of water, and by its pressure the sea water creeps up into the tube, and by the discoloration of the chemical that has been put inside of it, it is readily seen and measured how far the water has penetrated. From this data the depth may readily be calculated.

Many devices like this, which I found in the museum of the observatory, I would like to tell you about, but time forbids. From Hamburg I went to the celebrated works of Sir William Thompson, in Glasgow. He is one of the few scientific men who has made money. He has made a great deal of money and his great reputation is a deserving one. Not one of you who has sailed across the Atlantic ocean, but has seen his compasses or other scientific nautical appliances. I had the pleasure of visiting the works where his electrical apparatus is made, but unfortunately they were not working, it being Saturday afternoon. I, however, visited his laboratory at the university where I was shown many of his inventions, and was much interested in the experiments shown me.

At the great exhibition I saw a great many things that would interest you. I met an amateur astronomical instrument maker in Glasgow, Sir Archibald Campbell, who was president of the exhibition. He invited me to visit his works. At the exhibition he had three defraction gratings which he showed me. He said he did not think they were very good, but that the next one would be a great deal better. I hope it will. They have tried to make them all over Europe for the last twenty years. I did see one at Leipsic, however, that was quite beautiful. Sir Archibald also exhibited a very finely mounted reflecting telescope that had some novel and useful devices, and the workmanship was very fine. It was made for his own use only and not for sale.

Passing over from Scotland, I went to the works of Sir Howard Grubb, in Dublin, Ireland. I had expected much and was not disappointed. Sir Howard made the great Vienna telescope, and when a German will come up to Ireland to get a telescope you may know he had a good opinion of the man. I fancied I could almost see the tears in his eyes when he said: "What do you think they are doing over there with my great telescope? They are having it for a show. They have it in a great, big, beautiful observatory in Vienna and people go there and *look at it*, but what has the telescope ever done?"

Prof. Simon Newcomb, the man we consider our American expert, visited the Vienna Observatory in 1885. He made a series of observations with the great instrument and pronounced the images very perfect, indeed, and that Grubb deserved the great-

est credit for making so fine an instrument, at the time the largest in the world. Lockyer once said: "It would make no difference what they made in Europe. We make as big a telescope as we please, but the Americans will always make one an inch bigger." But our record is now nearly seven inches larger than any yet made in Europe.

At the time I was there Sir Howard was making a 28 in. for the observatory at Greenwich. He was very kind to me. It is said that when Alvan Clarke was over at his works he would not take him through his sanctum, but Sir Howard showed me everything about his works, and I must say, of all the mechanics I met in Europe I consider Sir Howard Grubb the peer of any and his work equals the best. American engineers have adopted his great observatory dome and its accessaries almost complete; and they have given him due credit for it—they acknowledge it. In the great Lick Observatory many of the plans were originally gotten up by Grubb, entirely, and is considered the best ever devised for such large telescopes.

[Mr. Brashear here described a new form of solar and stellar spectroscope.]

I have brought here for you to see an instrument which we have recently finished. I must give credit to my assistants for getting it here to-night, as some of the parts were not put together until to-day. I shall be pleased to have you examine it and ask me any questions you desire.

I desire you to notice particularly the engraving on the graduated circle. I have always had great difficulty getting that sort of work done here. This was engraved by a new machine in an incredibly short time, and is very perfect indeed.

Mr. Brashear here gave a description of the working of the instrument, the spectroscope. Several questions were asked in regard to the instrument, which were answered in detail.

In the general discussion, Mr. Metcalf asked if in the driving clock described the rod was fastened at the bottom.

Mr. Brashear: Yes, fastened solid at the bottom. The drawing I have made here is an exaggerated one. For driving the heliometer the rod is about 15 inches long. The rod I saw revolving probably at the rate of 300 or 400 revolutions per minute.

A MEMBER: What is the focal distance of that new equatorial instrument at Paris?

MR. BRASHEAR: I am not certain of this matter. The focal distance will depend on the focal length of the objective. It looked to me about the focal length of the ordinary telescope, but it was probably longer, and those who understand the principle of the telescope know that the color correction is always improved the longer the telescope, and telescopes would be made much longer than they are were it not that the engineering problem of mounting them is increased this way. I want to add another thing, that the astronomers find the two silvered mirrors deteriorate very rapidly in the atmosphere of Paris. They last about six months, but silvering is a very small matter and they are glad to do it. But Dr. Loewy has done a very sensible thing in the new instruments. The objective will be placed on the *outside* of the mirrors instead of inside as in the old form, which will have the advantage of inclosing the mirrors, thus protecting the silver surfaces from rapid deterioration.

Remarks were made by Prof. Frost and Mr. Metcalf.

The President was authorized to appoint a committee to report candidates for election for the coming year, and report at the December meeting.

On motion adjourned.

A. E. HUNT,

Secretary, pro. tem.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

This Society does not hold itself responsible for the opinions of its members.

PITTSBURGH, Dec. 18th, 1888.

Society met at 8 o'clock P. M.; Vice President J. A. Brashear in the chair.

Vice President W. L. Scaife and Messrs. Hunt and Davis, Directors, and thirty-six members being present.

Messrs. J. B. Jenkins, Jas. Purves, Chas. F. Miller and W. J. Holland were duly elected members.

Mr. Hunt read a paper, prepared by J. E. Greiner, C. E., on

THE B. & O. TRAIN SHEDS AT PITTSBURGH, PA.

The design of a train shed does not usually call into play much engineering ability, in fact nothing new or particularly troublesome is met with in the calculations, fabrications or erection of such a structure. Still, when taken in connection with a magnificent depot, the two combined into one immense building, there are certain features which must be of interest to anybody desirous of being up to the times, and knowing a little more of the details of new work than can be obtained from newspapers or by a superficial examination of the structure in course of building.

At the time of writing, the designs and plans of the depot proper are in the hands of the architects and not available for convenient reference; as a consequence, the main portion of the present paper will be confined to a detailed description and an analysis of the calculations and design of the Train Shed, the author being more conversant with this part of the work.

The floor of the shed will begin at the abutments built on the east side of Grant street, and making an angle of 75 degrees 40 minutes with these abutments extends along the wharf for a distance of 422 feet, until it meets and is connected with the depot

near Smithfield street. The floor system is supported by 32 pedestal posts, there being 3 lines spaced 42 feet centers laterally and 38.5 feet longitudinally, varying in height from 8 feet 8 in. to 30 feet 10 in., according to the slope of the wharf. The section is made up of 15-inch plates and 3½x4 angles strapped together by heavy lattice bars. These posts have enlarged bases, 40 in. x 40 in. for the center line and 32½ in. x 32½ in. for outer lines, thereby making the maximum pressure that can ever bear on masonry 300 pounds per square inch.

They are anchored down by four bolts 1¼ in. diameter, are connected together in pairs by stiff longitudinal struts placed near the top, and by knee braces securely connecting them to the cross girders. There will be a clear head room under the entire structure of 12 feet 9 in., and the passage to and from the water impeded as little as possible.

There will be twenty-two floor beams or cross girders resting directly upon the top of pedestal posts, being secured by four ⅞-in. rivets at each end. The length is 42 feet; depth, 5 feet, subjected to a flange strain of 406,900 pounds and requiring 50.86 square inches of metal in one flange alone. The cross girders being thus securely fastened to the posts, the expansion and contraction due to changes in temperature will merely deflect the pedestal posts a little beyond the plumb line.

There will be very little change in length, however, since the iron work is protected by a wooden floor, thus keeping out the rays of the sun, and it is probable that with the extremes of temperature the length of the 42-feet cross girders will not vary more than ¼ in. There is one point, however, where it was considered desirable to make an expansion joint, and that is at top of post marked C in plan. It will be seen that one end of cross girder B C rests on the masonry, the other on post C, and the floor beam being firmly anchored to the masonry, the slip joint was made where the two cross girders abut. The girder B C is lighter than the others and is but 4 feet 2 in. deep. The joint is shown on the detail sheet.

There are four tracks to be supported, consequently eight lines of main stringers or longitudinal girders 38 feet 6 in. long and 4 feet deep, which are riveted directly to webs of gross girders. In addition to these track stringers there will be four lines of girders for carrying the passenger platform. Provision for expansion has

been made in a very simple and common way, viz., at expansion end the weight is supported entirely by a bracket or shelf riveted to cross girders, while the end of the stringer, thickened by reinforce plates, so as to have ample shearing area, passes between the projecting legs of two angles riveted to cross girders. The girders are held in place by two bolts, $\frac{7}{8}$ in. diameter, passing through finished round holes in the angle legs and through 2 in. x 1 in. slotted holes in web of girder, thus, while holding the stringers firmly laterally and vertically, there is at the same time freedom for longitudinal motion.

The floor or platform will be on the same level as top of rail throughout the entire shed, thereby facilitating the passage of trucks across from track to track. Two and a half inch white oak planking will be used, laid lengthwise or parallel with the tracks, and supported by 12 in. x 2 in. joists under passenger platform and by ties under rails. All that portion of the floor which lies between the end of the shed and the west abutment will be made of 3 ft. x 3 ft. x $\frac{1}{4}$ in. buckle plates, filled in with granolithic or some similar material, which will make a good and permanent road bed. In order to hide or cover the ends of the I beams which support these buckle plates, a cast-iron moulding, conforming in shape to the coping of abutment, will be connected to them and extend from the stone coping to the first post supporting the roof. From this post, throughout the entire length, a moulding of wood and of neat design will cover the ends of floor joists. The railing extending along the sides of shed will be entirely of wrought iron and quite ornamental in design. All these details are shown on drawing.

The *shed* will begin at Grant street abutment, extend a distance of 385 feet, or to within 32 feet of the east wall of station. It is composed of nineteen intermediate trusses—span, 84 feet; rise, 21 feet—and two end trusses of same span and rise, making in all twenty-one trusses, supported upon forty-two posts of]|[section, about 22 feet high, resting on top of cross girders at their ends and on top of the outside longitudinal girders at their middle. The end trusses were made with vertical compression members in order to give better facilities for glazing and boarding in the gable. The end truss at the east end is also stiffened to resist any wind which might blow against its covered gable. Trusses are connected to

top of each post by four ¾ in. bolts, all lateral expansion being taken up by the flexibility of the posts, or, in case these prove too rigid, the truss itself will simply rise or fall a little as the case may be. A good strong bracket of wrought iron adds lateral stability by firmly uniting the main rafters with the posts, whilst longitudinally all the posts are connected by trussing and brackets, as shown on drawings. The main rafters will be of seasoned long leaf yellow pine; all other truss members of wrought iron.

Between the main train shed and the east wall of station there will be a wooden truss with rafters running perpendicular to those of the shed, or, in other words, the gable end of this part of the structure will face Water street. The tracks, of course, will extend no further than the end of main shed, where a line of gates will prevent the passengers passing to the train until the proper time.

The foregoing description, with the aid of accompanying drawings, will, I think, convey a general idea of the character and size of the New Train Shed. It should at least be sufficient for the present time, since the whole work has been under contract since the last of August, and should be finished completely in four months from the signing of contract.

The total weight of iron in the structure is divided up as follows:

Pedestal Posts	115,100
Cross Girders	404,200
Longitudinal Girders	841,100
Upper Posts	56,900
Trusses	82,400
Braces and Brackets	113,500
Cast Iron	14,200
Miscellaneous	81,100
	1,708,500

EXTRACT FROM SPECIFICATIONS OF PITTSBURGH TRAIN SHED.

LUMBER.—All lumber to be of the best quality of the respective kinds herein mentioned, perfectly seasoned, sound and free from all large or injurious knots, sap, shakes, or waney edges or other defects, and to be of full dimensions.

GEORGIA YELLOW PINE.—All roof and truss timbers, rafters, purlins, etc., to have ornamental sawed ends; purlins to be notched down 1 in. on trusses, 1⅛ in. t. g. and beaded; sheathing not over 3 in. wide, laid at an angle of 45 degrees to rafters on that part of roof inside of barge boards, reversing the sides; that part outside of barge boards and the ventilator to be laid with sheathing at right angles to rafters, ⅞ in. t. g. and beaded; siding at ends where indicated to be beaded on both sides when both faces are exposed.

WHITE PINE.—All barge boards, sash pieces, mouldings, heads, curbs for skylights, ventilators and casing of ventilator posts, moulding and facia piece to enclose ends of joints.

WHITE OAK.—2½ in. x 8 in. thicknessed flooring with butt joints tightly wedged up and thoroughly spiked to joint; 2 in. x 12 in. joists, 3 feet c. to c., notched on to stringers and furred up, as shown, to receive flooring between rails. Floor boards to be kept 1⅝ in. clear of both sides of rail, and to have edge towards rail chamfered.

SKYLIGHTS.—Put up Vaile and Young's (Balto.) patent skylight, with beveled bar and ¼ in. ribbed glass, where shown. The contractor to do all flashing, etc., around skylights with same tin as below. All to be put up in perfect manner and guaranteed against leaking.

FELT.—All tin to be laid in O. K. straw building paper. (H. W. Webb & Sons, Balto.)

TIN WORK.—Cover all the roofs and do all the flashing and counter flashing, wherever necessary, and line all gutters, which must be properly graded to down spouts, with Gilbertson Old Method (Merchant & Co., Phila.), charcoal-leaded I C tin, each sheet to be stamped with brand and thickness—14 in. x 20 in. for roofing—laid with 20 in. way down the roof; to have two cleats to each sheet and two 3d galvanized nails to each cleat.

DOWN SPOUTS, SPOUT BOXES AND STONES.—Five inch galvanized iron down spouts of Irwin & Reber (Phila.) pattern, properly secured in place with bands and hold posts. Put a down spout in every other post, beginning with the first and ending with the last post of the shed, making twenty-two down spouts. The down spouts to be fitted at foot into square, ornamental, cast iron down spout boxes of approved design, five feet high, with base moulded

to fit over coping of masoury and carried down to ground, where it is to waste on 12 in. blue stone spout stone set in paving.

Snow Guard.—Put up a $\frac{3}{4}$ in. galvanized pipe guard on roof of ventilator, running along on each side the full length of roof, and put up in the most secure and substantial manner.

Cast Iron.—All ornamental cast iron work must have a smooth finish and be free from air holes, cinder spots or other imperfections. All castings must be true and out of winde, and all joints must be dressed to a perfect fit.

The end finish castings for the north and south sides of east and west abutment bridge seats are not to be furnished until after the erection of the floor and the other castings are placed, when drawings for these castings will be made from exact measurement.

Glass.—Glaze the sash at both ends of shed with 14 in. x 20 in., second quality, single thick Balto. glass, well bradded and puttied and back puttied, and hung with galvanized iron clips, one under each end of glass.

Paint, Wood Work, Roofing and Spouting.—All wood work inside of barge boards to be oiled two coats best linseed oil and then varnished. All wood work outside of barge boards to be painted three good coats linseed oil and white lead of such color or colors as the resident engineer may select. All tin and galvanized iron work to receive two coats of Druid Elastic Paint, brown (Druid Elastic Paint Co., Balto.), on each side.

Wrought Iron.—The Baltimore & Ohio specifications for workmanship and quality of material for wrought iron bridges shall apply in full to all iron work.

Remarks might now appropriately be made concerning the data and methods of calculation employed in designing the shed. As a premise to such remarks, it can be stated that many engineers, especially of the old school, do not approve of much mathematical refinement in the calculation of strains or in proportioning sections, considering the time necessary to obtain careful results as a waste of mental energy wholly uncalled for by the problem in question, since ample allowance is made for approximate results by using a large factor of safety.

The author recently heard one of the most prominent bridge engineers in the country maintain that the proportioning of bridge

members is but the roughest kind of guess work, the strains deduced by calculations being merely a foundation upon which to base this rough guess. Whether this engineer really believes his own assertion, or merely advanced this opinion in justification of an enormously heavy structure which he desired adopted in lieu of plans proposed by the author, it is impossible to say; at any rate, he did not succeed in bringing the decision in his favor. Such views are not tenable, and a structure designed in such a way will be neither economical nor will it stand critical examination. True, judgment in many cases must assist or augment the scientific conclusions, but judgment and guess work are entirely different things when bearing on subjects of such a nature.

That the proper design of all framed structures is founded upon strictly scientific reasoning and principles goes without saying, and while, perhaps, fifty years ago an engineer was excusable when he designed his structures of wood, then a plentiful and cheap material, without any recourse to mathematical preliminaries, at the present time a demand for economy which is safe and based upon undisputed principles has completely overthrown this old rule of thumb method, and places the design of all structures of any prominence in the hands of men who govern their actions by well established reasoning and a knowledge quite up to the present state of engineering advancement.

When the designer proportions his structure from given data it will be more or less correct according to his methods of procedure. If the data is erroneous we should not sneer at conclusions properly derived, but should rather aim to modify the premises to meet the case in question.

This continual sniffling at what is termed *excessive refinement, hair-splitting accuracy, etc.*, is, I believe, only met with in this country, where the whole aim of engineers and those who require their services is to accomplish the greatest possible amount of work in the shortest possible time. Of course, when thus pressed, the engineer has no chance for clear thinking or reasoning, but must dash into his subject without any preliminary skirmishing and make the most of his handy tables. In this way a bridge company's calculator turns out a remarkably large number of estimates during the year, but he is developing into a sort of *live calculating machine* without being aware of the fact.

It has long been the custom when designing roofs and such structures, subject to a static load and an intermittent wind pressure, to lump both pressures and consider them as acting vertically, or else to consider the dead load vertically and the wind horizontally and then combine the results.

While such assumption might be sufficiently close for the purpose of tendering bids, still they are not altogether correct when viewed from a more considerate standpoint. It has been amply demonstrated by experiment that when wind impinges upon an inclined surface the action will be normal to surface, but of a greater intensity than the normal component of the horizontal force.

The intensity is expressed by the formula:

$$Pu = P \sin i^{1.84 \cos. i-1}$$

Where Pu = normal component,

P = horizontal pressure per sq. ft.

i = angle which the inclined surface makes with the horizontal.

If the action of wind be considered in this manner the resulting stresses will in some cases be decidedly different from those obtained by using a vertical force alone. From this we see that there can be no possible excuse for neglecting the horizontal force of wind properly reduced, excepting that of lessening the amount of labor in our calculations, in which case, however, the before-mentioned prominent bridge engineer would be justified in stating that the strains represent "a very rough guess."

Further, when a truss is supported upon a wall or other inflexible support, provision is made for expansion by using rollers at one end, in which case the stresses will not be symmetrical on both halves of truss.

The correct design of a roof truss involves three cases, as follows:

CASE I.—Vertical static loading, including weight of snow, roof covering, purlins, truss, etc.

CASE II.—Effect of wind on leeward truss for roller and fixed ends.

CASE III.—Effect of wind on windward truss for roller and fixed ends.

The actual maximum stresses will be found by properly combining these three cases, and in addition to these there will be a bending in the main rafters when purlins do not rest directly over panel points, which bending must be resisted by the material in the rafters.

When, like in the present example, a roof is supported upon flexible columns, it becomes necessary to stiffen the columns and connect them to the trusses in such a manner that there will be no danger of the structure collapsing under a heavy wind pressure, and still leave sufficient flexibility to admit of a little lateral deflection due to changes in temperature affecting the length of trusses. This stiffening is done by connecting the columns to rafters by means of brackets designed for their peculiar duty of resisting all tendency to collapse and be slightly flexible at the same time. The introduction of such a bracket between posts and main rafters will, of course, affect the strains in some of the truss members, therefore the common practice of neglecting its influence upon the strains is erroneous and should not be tolerated by careful men.

For instance, let Figure 1 represent one of the main trusses subjected to the action of a wind force of thirty pounds per square foot, horizontally the normal effects of which is eighteen pounds per square foot. This will give 4,070 pounds at each intermediate panel point and 2,035 pounds at apex and at extreme end of bracket.

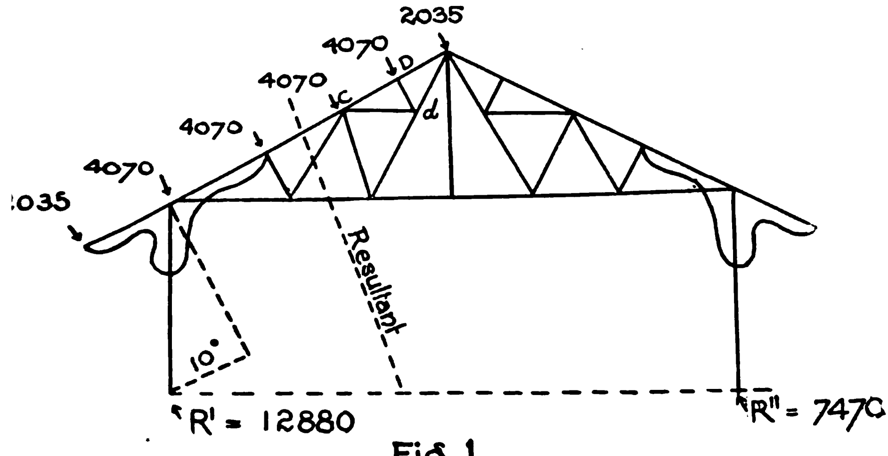

Fig. 1.

The resultant of these forces acts on the dotted line, which being produced until it intersects the line connecting the bases of posts will divide this base into two segments proportional to the reactions at foot of posts. These reactions are 12,880 at R′ and 7,470 at R″, and act in a direction parallel to resultant. From the figure we see that foot of post is 10 feet to left of line drawn through its top parallel to direction of forces, consequently there is no difficulty in seeing, from a very casual inspection, that the effect of the bracket will be to modify the strains in all members excepting Cd and Dd.

Hence it is obvious that the sometimes practiced custom in such cases, of considering the reactions at top of posts, will not by any means give the required maximum strains.

The author has also known engineers to figure stresses, in roof trusses supported on columns, from vertical and horizontal pressures without considering that the effect of the horizontal is normal to slope. In figuring from this basis they would contend that the tendency of wind was to overturn the entire structure about the base of leeward column, overlooking the important fact that in such structures there can be no overturning, the effect of a horizontal wind pressure being to crush the roof down to the ground and hold it there, unless indeed the supporting posts are so high or the slope of the roof so steep that the center line of gravity of the normal pressure passes outside the post pedestals, in which case, of course, there would be an overturning tendency, producing compression in the leeward and tension in the windward posts.

The roof in the present case was designed from the following data:

Length of span	84 feet	0 in.
Depth of center	21 "	0 "
Distance between trusses	19 "	3 "
Height of posts	22 "	4 "

Case I.—Vertical static loading:

Snow per square foot	12 lbs.
One-inch planking covered with tin	7 "
Purlins, etc	5 "
Per square foot	24 lbs.

Weight per lin. foot for truss covering........460 lbs.
" " " truss only............100 "

Total per lin. foot.........................560 lbs.

CASE II.—Strains due to wind blowing horizontally with a pressure of 30 pounds per square foot, the normal effects of which is 18 pounds. Windward half of truss considered.

CASE III.—Wind as before. Leeward half of truss considered.

The maximum strains will result from a proper combination of above, and, in addition to which, the main rafters are proportioned to resist a bending moment due to 800 pounds per lin. foot uniformly distributed.

Working Loads:

Tension...................... 15,000 lbs. per sq. inch

Compression:

Square Ends.	Pin & Sq.	Pin Ends.
$\dfrac{10{,}000}{1+\frac{1}{36{,}000}\left(\frac{1}{r}\right)^2}$	$\dfrac{10{,}000}{1+\frac{1}{24{,}000}\left(\frac{1}{r}\right)^2}$	$\dfrac{10{,}000}{1+\frac{1}{18{,}000}\left(\frac{1}{r}\right)^2}$

Yellow Pine in direct compression, $\dfrac{1{,}050}{1+.002\left(\frac{1}{d}\right)^2}$

Timber for combined and bending not to exceed 1,200 pounds per square inch.

Concerning the calculation nothing need be said, since the conditions and data above given indicate clearly the method pursued.

The lower portion of structure, embracing the entire floor system, was designed to carry B. & O. 94.6 ton consolidated engines, followed by 3,300 pounds per lin. foot, and in addition to this, 100 pounds per square foot, covering the platform between tracks, the allowed working strains being those given in B. & O. specifications for railroad bridges.

For the strength of pedestal posts and stability of structure, two cases were considered.

CASE I.—Maximum loading on posts in combination with maximum wind pressure.

CASE II.—Minimum loading on posts in combination with maximum wind pressure.

Case I, of course, gives the maximum direct strain, while the maximum bending will result under the condition of Case II. The direct strain in no case exceeds the safe working load derived from square bearing column formulæ with factor 5. Bending strain in extreme fibres does not exceed 12,000 pounds, or bending and direct combined 14,000 pounds.

Discussion of Mr. Greiner's paper on the

B. & O. TRAIN SHED.

MR. BARNES: At the time this subject was suggested in the Committee on Programme, several months ago, it was believed that we might secure some description of the station in connection with its approaches, as the topic has been kept before us for some years.

The impression seemed to prevail also that there would be some rearrangement of the freight tracks in the new structure, and it was hoped that the whole scheme complete would be brought out in the description.

It appears, however, that it has taken a different form, interesting and useful in itself, but I could wish that something had been given of a more general character, touching the whole arrangement.

MR. BECKER: I notice that on page 8 Mr. Greiner says, "It has been the custom to lump both pressures," etc. That would lead one to suppose that his own method of determining the stresses was something novel, which, in fact, is not the case. On the contrary 15 years ago I know we built a station at Columbus, the clear span of the roof of which was much greater than his; it was, I think, 115 feet, while his is only 84 feet, where we pursued the same method precisely in determining stresses as has been done in this case. Mr. Johnson, who is here now and who made the calculations, can tell you whether I am correct in the matter.

MR. JOHNSON: Mr. Becker is entirely correct in that matter. Mr. Greiner has made three cases where we made four. We took the case of snow upon one-half the roof, both to windward and leeward.

Mr. Hunt: I would like to ask whether the unit strain of 15,000 lbs. per square inch is not fully up to the maximum, especially in members that may be subject to impact and to sudden wind strains.

Mr. Becker: I think it shades it pretty close. Still, for that portion of the shed which merely embraces the shed proper, I think that 15,000 lbs. is still safe. For that lower portion, which is subjected to locomotive loads, I do not think it is enough. I do not think it ought to exceed 10,000 lbs. per square inch.

Further discussion postponed.

Discussion of T. P. Roberts' paper, which was read on the 16th October, on the

Railroad Situation of Pittsburgh.

The President called on Mr. Becker to open, who stated that he had been rather startled to read in the morning paper that he was expected to join in the discussion on this subject. That he had not intended to come, but later in the day he had received a communication from Captain Hunt which he felt he could not disregard. He had therefore taken a little time to write down a few points which had occurred to him as being pertinent to the subject, and as they dealt with figures he would read them.

The substance of T. P. Roberts' very interesting paper may be summarized as stating that the situation in and about Pittsburgh precludes the establishment of additional railroad facilities in the shape of circular, or so-called belt lines, and that the only practicable space remaining for additional railway lines, is along the shores of the rivers, which he says could be made available for that purpose by a proper system of riparian improvements.

Now, as to the first proposition, there can be no question or dispute. No engineer of ordinary common sense would propose, and certainly no intelligent business man would be willing to furnish the means for building a railroad around this city, over or through hills 500 feet high and across valleys 300 feet deep, half of which line would be under ground and the other half up in the air, and the whole inaccessible for business.

The simple fact that nine out of the ten railroads entering this city

lie in the valleys of the rivers, seems to indicate that there is the natural place for them, from an engineering point of view. They were built there because there was the business which they sought, and the business is constantly concentrating there because the railroads are there.

The only question then remaining, on which any issue with Mr. Roberts could be taken, is that of the "immediate necessity for enlarging the facilities of the railroad's passage through the city of Pittsburgh."

Mr. Roberts is rather non-committal as to whether this result could be best accomplished by the introduction of new lines, or by more extended facilities for the existing ones; his observations on this point are more ironical than instructive. But judging from their undertone, I would infer that he would rather favor the advent of additional lines; and in the absence of other reasons given for this implied preference, I presume it is on the general principle of the "*more the merrier*." We have now, including the Junction road, eleven lines of railroads entering the city; all, excepting the Pennsylvania Railroad and a portion of the Junction Railroad, follow the valleys of the streams. These eleven lines are owned and controlled by four corporations. Of the volume of freight shipped from and received at this point, I regret to say I have not had time to obtain any satisfactory information, but I am quite ready to admit that, in proportion to the population, it is perhaps as large, if not larger, than that of any other city in the world. But in the absence of better information regarding the volume of freight business done by the railways in this city I cannot, of course, express any opinion as to the adequacy of the means for handling and disposing of it. Perhaps a comparison of the passenger business done here with that done at some other points may be interesting, and at the same time may afford, at least by inference, some idea of our general available facilities and our actual necessities.

The eleven railroads centering here bring in and take out daily, altogether 395 trains; this includes the trains stopping at and departing from Allegheny City. These 395 trains arrive and depart from seven distinct and separate stations. The trains arriving at and departing from the Union Depot daily, number 227;

leaving 168 trains to enter and depart from the other six terminal stations. For the Union Station this would make one train every six minutes, nearly. At all the other stations trains arrive and depart less frequently. All the seven passenger stations, and not less than six principal freight stations, are located within a circle of one mile radius from the court house. The lines penetrate, therefore, well into the heart and business center of the city, and there is in fact but one space, covering an area of about seven square miles, within the limits of the city, which is not reached by a railroad, and that is in the suburbs, beyond the general range of manufacturing works, between the Pennsylvania Railroad, the Junction Railroad, and the Monongahela river, in the eastern portion of the city. Pittsburgh, including Allegheny and the immediate adjacent suburbs, has a population of about 350,000. It has eleven railroads with seven terminal passenger stations in the very heart of the city, and 395 daily trains arriving and departing. Now it is but fair to presume that this is sufficient for present wants, as the supply in this commodity is generally about measured by the demand. The question then is as to the future; can the present facilities be expanded to satisfy the necessities of the future? The only rational way of answering this question is by comparing our own situation with others and then draw our conclsions.

The city of Philadelphia, with about 1,000,000 inhabitants, has to-day thirteen railroads owned and controlled by three corporations; its passenger business is done at nine stations. The number of trains, regularly scheduled, arriving at and departing daily, from the Broad Street Station of the Pennsylvania Railroad, is 401, not counting second sections nor the return switching of empty trains after discharge of passengers. This makes a train every three and one-half minutes. During the busy hours of the day trains come and go at intervals of two minutes and less. The business at the Jersey City Depot and the Forty-second Street Depot of the New York Central is, at certain hours of the day, nearly equal to that of the Broad Street Station in Philadelphia.

While these performances seem marvelous, yet they appear very insignificant when compared with the results reached in this line by the English railways in the city of London. You may know that the city of London proper, covering an area of about ten square miles,

is surrounded by the lines of the Metropolitan Railway and the Metropolitan District Railway, whose tracks are chiefly under ground, and whose length is 42 miles, laid all with double tracks, and at a few points with three and four tracks. Of the trunk lines which traverse the country only ten enter the city of London, and have their terminal stations at different points on the circumference of the circular railway of the Metropolitan system, where the exchanges of traffic take place. None of the trunk lines penetrate inside the circular lines of the Metropolitan system, and the population within the circle must rely upon stages, carriages, and tramways for its movements. According to a recently published book on London Railway Terminals, by Sam Rea, a former Pittsburgher, now assistant to the vice president of the railroad, there arrive at and depart from the Waterloo Bridge Station, the terminal of the London & Southwestern Railroad, between the hours of 9 in the morning and 10 in the evening, 1,000 trains, or one train every 54 seconds. These astonishing performances are, of course, but the simple and logical consequences of the pressing necessities called forth by the daily movements of 4,000,000 of people. Now with these facts before us, do you think it really worth while to lay awake of nights worrying about the future needs of our city, or may we not safely trust to the inventive genius of our own people to solve these questions as they come up? It may be wise to look ahead and provide for the future, but investments in advance of necessity find very little encouragement, while on the other hand, all obstacles will naturally be removed when the proper time arrives to overcome them. It may cost more money then to supply our wants, but what of that?

The city railways of London cost from $2,000,000 to $3,500,000 per mile, but they pay good dividends all the same. But all this is too remote to dwell upon now. All our present wants, and those of the immediate future, can be readily satisfied by a mere gradual application of means and methods which are known to be efficient and reliable. By the more general introduction of the electric signal system alone the despatching of trains and their speed can be greatly improved and at the same time much added to their safety. Where the tracks were heretofore ablaze with the bewildering swinging of innumerable lanterns in the hands of

blaspheming switchmen, while the trains were slowly picking their way through the confusion, waiting here for the opening of a switch, and stopping there to pick up the brakeman after closing it, the trains now glide noiselessly along under the absolutely safe guidance of a single man at the levers of the interlocking machine in the little tower above. Then consider the constantly increasing capacity of our motive power and rolling stock. Less than fifteen years ago, our largest engines had all they could do when they hauled eighteen freight cars, loaded with ten tons each, over the road from here to Steubenville; to-day our Class R engines pull twenty-five cars loaded with thirty tons each, an increase in capacity of 350 per cent. While we actually do this increased business in less time and with less trouble, and, I am sorry to say, for less money than ever before.

In the course of a few remarks on this subject, on the night when Mr. Roberts' paper was read, I said that undoubtedly the constantly growing local traffic would eventually absorb the space and facilities now devoted to the through traffic of our railroads; but I also said then, and I can only repeat it now, that when this time comes, the through traffic will have to be diverted over routes outside of the crowded city at any cost, and in spite of every obstacle, and if after that the local business still requires additional room, I do not know of a better place to find it than on the banks of our rivers, prepared for that purpose in the manner suggested by Mr. Roberts. But still I think that the further discussion of this subject can be safely left to a select committee composed of the great grandchildren of the present members of this Society.

EMIL SWENSSON: I am not in the same box as either of the gentlemen who have been heard on this question. I differ in some respects from both Mr. Becker and Mr. Roberts. I heartily agree with Mr. Becker in the first part of his paper, but not with the latter part. I think we need further facilities in the city of Pittsburgh, that is, in getting the freight business around the city.

Then I think Mr. Roberts is a little hasty in saying that putting the tracks on the built-up river banks would have no appreciable effect on the rivers. I have examined the points a little and found that for every 40 feet taken from the rivers in the way of banks

there is a little less than one foot increase in the elevation of the high-water mark, if the velocity would not increase, and the present velocity at high-water is more than our river men can master. Then there is the considerable expense, both engineering and legislative, connected with filling in the river banks.

From constant reading of the *Dispatch*, I have been strongly impressed with the future greatness of Pittsburgh. We will soon have to further extend the city limits. But if we do so we have to remove some of our freight business outside of the city, especially the stock business, which now is a nuisance to East Liberty. My idea would then be to establish large stockyards, switching yard and freight yard out about Turtle Creek Station, and build another bridge over the Monongahela at Port Perry, like the one proposed at Brunot's Island; abandon the P. V. & C. tracks up to the city, do the same with the Panhandle road up to opposite Brunot's Island, bringing the P. V. & C. passengers in over the bridge at Turtle Creek, and the Panhandle passengers over the Brunot Island bridge into the city, both routes being shorter than the old ones. Then make 4 to 6 tracks over the line of these two roads between the bridges for carrying of through freight; this would cause the Union Station to be used solely as a passenger station, which is indeed sorely needed.

A. E. HUNT: There is another scheme, which I noticed in one of the late Sunday papers. It may be an entirely Utopian one, but I mention it here for what it is worth. It is to divert the Monongahela, and the Allegheny river also, if necessary, from their beds to new channels around the city. The Monongahela around back of Mt. Washington and to come out at Sawmill run. The Allegheny to go around Allegheny City and enter the Ohio at Jack's run.

C. B. PRICE: After having heard from Mr. Becker so fully and intelligently on the subject, I feel that there is scarcely anything to add to it. I agree with him that we need not lay awake of nights on account of the inade quacy of the railroad facilities of Pittsburgh. No doubt as the present facilities prove inadequate some better plan will be followed, some other system of train handling, whereby through shipments will be carried around instead of through the city, ere we are compelled to adopt Mr.

Roberts' plan, as I understand it, of bulk-heading the rivers at the low water mark. I do not think that need be done next year, or the year after, at any rate.

M. J. Becker: There is one part of Mr. Roberts' paper I had hoped some hydraulic engineer would take up and discuss. I do not feel able to do it myself, and yet I would be very much pleased to have some further discussion on that matter, and that is whether these rivers can be contracted in the manner Mr. Roberts suggested. In other words, whether it is true, as he stated, that the rivers are wider now than they were years ago, for the reason that the wave action would tumble down the banks; and also whether the conclusion is correct, which he drew from the presumption that anything which could be put through a two feet square box at a place above, can be put through a box of the same area again below, provided there has been no increase of volume, no matter how much the distance between the two boxes. This is all very well, and yet it does not strike me as perfectly convincing.

There is one thing I am pretty certain about, that whatever material tumbles down from the banks goes some place. I think a large part will be found at the bottom, not far from the place where it fell, some will be held in solution and go down the river. A great deal of the material that tumbles down from the banks simply raises the bed of the stream. In other words, while it may widen the channel it makes it shallower. All over Europe the rivers are confined within artificial banks. Wharves are built out where the vessels can land in deep water, and altogether it is much nicer, has a better appearance, increases the facilities, makes the current of the stream more uniform.

Chas. Davis: I might say this, that as far as my observation goes the streams here are much narrower than some years ago—this narrowing is quite noticeable in the Allegheny near Herr's Island and below the Suspension Bridge, and in the Ohio below the Point. The Monongahela below Dam No. 1 has been in many places considerably contracted. The contraction at some points on all the rivers is beyond the legalized lines.

A. J. Hoag, Jr.: Yes, but that is due to artificial causes.

Mr. Davis: I have watched these streams very carefully and I think Mr. Becker is correct in his opinion as to the effect of the

washing of the banks—that the most of the material is deposited close by and that the tendency is to lift the bed of the stream. I think we are doing wrong in encroaching on the river in this way by putting out irregular embankments and other obstructions in the bed of the stream. This encroachment or narrowing is done without any system. I have noticed river regulation work in many towns in Europe, especially on the Danube; there everything is done according to well-matured plans. A start was made here in this direction in 1861 by the establishment of high and low water lines for the portions of rivers lying within city limits of the two cities, with a view of normalizing the widths of rivers, settling riprarian rights and improving navigation, but the improvement of the shores in conformity with this plan has not been followed out. If this could be done I believe it would be beneficial.

I do not agree with Mr. Roberts that this territory could be appropriated for railroad purposes. I think the time will come when we will need much of it for facilities for handling freight for our waterways, and that after a while waterways will take a more prominent place than they have done lately.

Of course the railroads can handle certain classes of freight to much better advantage than can be done by water, but there is a class that can be moved by water quite as economically where speed is not important. And these large manufactories and industrial establishments must have water facilities as well as facilities for land traffic. I think we see this exemplified in the situation on the other side of the water; there the railroads go hand in hand with water lines of communication—they are not rival interests. And here in our cities, where we have the advantages of extended water communication, we should make the best of them by putting the banks in shape to receive the water trade and to improve navigation.

Then there is another thing, the appearance of the river front. On the other side the finest thoroughfares in river towns front the river. Here our river front is the worst part. This is all wrong. It should not be the worst. This matter will have to be readjusted and at a very great increase of cost over what it otherwise would be. The healthfulness of the cities would be greatly enhanced by broad improved open spaces on the river banks.

Mr. Hoag: I came here for instruction and did not expect to be called. I differ with Mr. Becker and also with Mr. Davis in regard to the effect from the falling or caving of banks. I have surveyed nearly every shallow from Pittsburgh to Cairo on the Ohio river many times, and I cannot recall a single place where the bottom of the river is formed of these washings. They are almost all of a hard character, of gravel and boulders, and, as I now recall it, the banks are of clay and alluvium. Of course after high water along the shore line, deposits of silt may be found, this is to be expected, but aside from that the bars between Pittsburgh and Cincinnati especially are of the described character.

C. B. Price: One point may bear discussion for a moment. One of the members has stated, as a matter of fact, that for every 40 feet we narrow the channel we elevate the water surface one foot. One would suppose, in a case of that kind, the practical result would be the deepening of the bed rather than the elevation of the surface. Is it not so, that such contraction of the channel is liable to cause scouring of the bottom of the river?

J. V. Hoag, Jr.: What is the reason, then, that at the island chutes it is as shallow as anywhere else? At the bridge pier you disturb the impacted character of the bottom, and it is then liable to scour.

A Member: I think the best answer that would be given as to the results of contracting the channel is from the results of Captain Eads' jetties.

M. J. Becker: I do not think so, because the Mississippi river has three or four other outlets besides the one at which the jetties are located, and it simply diverts the water that could not get out at one channel to the other outlets; but I am very glad that Mr. Hoag has given us a little of his experience, and I would like to ask one more question, whether his observations do not show that the deposits from tributary streams are on the increase, generally speaking.

J. V. Hoag, Jr.: Beyond a doubt. I presume the tributary streams bring in perhaps more than three-fifths of the alluvium carried in solution.

W. S. Wilkins: A very well-known principle in hydraulics is that the quantity of water dispatched is equal to the area multi-

plied by the velocity; there being no additional water from any side streams, if you diminish the area the velocity must increase in order to pass the same quantity of water, and if the velocity be increased to a certain extent it certainly will scour out the bottom. I think that has been found in the Monongahela river here, where one of the piers of a bridge was partially undermined by this scouring.

Mr. Hoag: Theory is good, but experience is better. Take at Neville Island, there is shoal water for the whole length of it. Why does not that scour? It is a continued shoal for five miles. It does not scour out for the reason that the bottom is hard. There is no alluvial deposit. Contracting the waterway of our principal rivers by 200 to 400 feet at their widest places would be a benefit to marine interests and accomplish the relief sought by Mr. Roberts' question.

E. Swensson: I can tell you of a practical experience we had in the city of Halmstad, Sweden. We wanted a harbor at the mouth of the river, and we had to build wharves along either side of the river for four miles, as it is very swamy on each side. We put down deep piling, facines and filling, and made it very solid, and then put first-class retaining walls on top. The result was that the height of the water increased, and also the velocity. This scoured out the bottom sufficient to give us depth for our vessels, as it of course could not scour out at the sides on account of the piling, and by this means we had a harbor deep enough without any extra expense for dredging.

Mr. Davison: As a matter of interest I will say that the first year the Mississippi River Commission got down to work I was in their employ on the Lower Mississippi. At the time I was there I believe I was in sight of about the widest and narrowest parts of the river. The widest point was at Bullerton Tow-head, just above Fort Pillow, where the river was two miles wide. The narrow point I refer to was at the site of Fort Pillow.

The point at Bullerton Tow-head which was two miles wide was not navigable during certain parts of the year by the ordinary steamers. The year in which I went there business on the river had to be done on very light draught boats. Right at Fort Pillow, the narrowest point I speak of, we attempted to find the depth at a

time when the water was near low-water mark, but we could not get bottom with 132 feet of line. It is very likely it was not so deep as that, because the lead would not sink vertically. The soil there is sandy. The width of the river is about 1,300 feet at ordinary stage. The Commission had instructed us to make observations covering a good portion of the river, so as to get data from which to work. I do not say that the river in widening had left any deposit on the bottom, but it had resulted in very shoal water.

A paragraph in Mr. Roberts' paper reads to this effect: "You may depend upon it that water which goes through a two-inch square box," etc. I am rather inclined to let these silly water courses remain as they are when bridging them. I think the streams have made their beds and they should be left as they are found when practicable and possible.

Adjourned, 10 o'clock, P. M.

S. M. WICKERSHAM,
Secretary.

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ABBOTT, A. V. Testing Machines.

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The Official Gazette of the United States Patent Office. Washington. Weekly.
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ENGINEERS' SOCIETY

OF

WESTERN PENNSYLVANIA.

CHARTER, BY-LAWS

AND

LIST OF MEMBERS.

INCORPORATED MARCH 20th, 1880.

PITTSBURGH:
PRINTED BY JOS. EICHBAUM & CO.
1888.

CHARTER.

To the Court of Common Pleas No. 1,
of Allegheny County, Pennsylvania:

We, the subscribers hereto, citizens of the Commonwealth of Pennsylvania, desirous of acquiring and enjoying the powers and immunities of a Corporation, or a body politic in law, do hereby associate ourselves under the articles, conditions, and for the objects, and in the name, style and title herein set forth.

ARTICLE I.—This corporation shall be styled and named, and bear the title of "ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA."

ARTICLE II.—The object of this corporation shall be the advancement of Engineering in its several branches, the professional improvement of its members, and the encouragement of social intercourse among men of practical science.

ARTICLE III.—Among the means to be employed for attaining these ends, shall be periodical meetings for the discussion of scientific subjects and social intercourse, the reading of professional papers, and excursions to examine objects of engineering interest.

ARTICLE IV.—Civil, mechanical and mining engineers, geologists, architects, managers and superintendents of railroads, mills and manufactories, and other persons engaged in scientific and mechanical pursuits pertaining to engineering, shall be eligible to membership in this corporation.

ARTICLE V.—There shall be two classes of members, Active and Honorary. Active members shall be persons who are actively engaged in any pursuit above specified, and who will participate

in promoting the interests of this Society, attend its meetings, present papers and vote at elections. Honorary members shall be persons who shall have attained eminence in any of the professions or departments of knowledge or labor mentioned in Article IV hereof.

ARTICLE VI.—Each person desirous of becoming a member shall be proposed by at least two members, and referred to the Board of Direction, and when favorably reported shall be elected by ballot at a regular meeting, upon receiving a majority of the votes cast, and shall become a member on the payment of his first dues, provided the same are paid within three months of his election. Honorary members shall be elected by a unanimous vote.

ARTICLE VII.—The name of any member may be stricken from the list of members, upon its being so ordered by the Board of Direction, and by a vote of three-fourths of the members of this corporation present at any annual meeting; due notice, however, having first been given to said member of such action.

ARTICLE VIII.—The officers of this corporation shall be a President, two Vice Presidents, a Secretary, a Treasurer, and four Directors. The President, one Vice President, Secretary, Treasurer, and two Directors shall be elected annually by ballot, by a majority of the votes cast at the annual meeting, and shall hold their offices until their successors are elected.

The President, Vice Presidents and Directors shall be eligible to but one re-election in succession. The offices of Secretary and Treasurer may be held by one person.

The President, and in his absence, the senior Vice President present shall preside, and in case of their absence a President *pro tempore* shall be chosen.

ARTICLE IX.—The Board of Direction shall be composed of the President, two Vice Presidents, and the Directors, elected by the members. They shall have the general management of the affairs of the corporation, shall hold monthly meetings at such times as they shall fix, and special meetings, when called for by the President or any two members of the Board of Direction, and shall report their transactions at each regular meeting.

They shall have power to fill vacancies in their own body, and

the persons by them chosen shall continue in office until a successor is chosen, and a special election therefor to fill the office and term made vacant may be had at any regular meeting.

ARTICLE X.—This corporation may make By-Laws not inconsistent herewith, nor with the laws of this Commonwealth.

WM. METCALF,
A. GOTTLIEB,
THOS. RODD,
E. M. BUTZ,
N. M. McDOWELL,
WM. KENT,
J. H. HARLOW.

I hereby certify that I have examined the foregoing Articles of Association of the Engineers' Society of Western Pennsylvania, and am of opinion that the objects, articles and conditions therein contained are lawful, and not injurious to the community, and within the proper power of the Court of Common Pleas to confirm as an incorporation, under the laws of this Commonwealth.

M. A. WOODWARD,
Solicitor for Applicants.

In matter of the incorporation of the Engineers' Society of Western Pennsylvania. } Common Pleas of Allegheny County.

And now, to wit, this 21st day of February, 1880, the foregoing Articles for the incorporation of the Engineers' Society of Western Pennsylvania being presented in open court, and perused and examined, and the objects, articles and conditions appearing lawful, and not injurious to the community, it is directed that the same be filed in the Prothonotary's Office of this Court, and that notice thereof be inserted in the Pittsburgh *Legal Journal* and *Commercial Gazette*, of this county, for three weeks, as required by law.

By the Court.

EDWIN H. STOWE, *P. J.*

In the matter of the incorporation of the Engineers' Society of Western Pennsylvania.

And now, to wit, March 20th, 1880, the Articles of Incorporation of the Engineers' Society of Western Pennsylvania having been, February 21st, 1888, filed in the Office of the Prothonotary of this Court, and due notice by publication in the Pittsburgh *Legal Journal*, and the *Commercial Gazette*, a daily newspaper of this county, made conformatory to law, and no exceptions being filed thereto; Therefore, on motion of M. A. Woodward, it is declared and decreed, that the persons so associated under said Articles shall, according to the said Articles, and the conditions in said instrument set forth and contained, become and be a corporation or body politic in law. And it is further ordered and directed, that said Charter of Incorporation shall be recorded in the Office of Recording Deeds in said county, and on being so recorded, the persons so associated, or meaning to associate, shall, according to the articles, objects and conditions in said instrument set forth, become and be a corporation or body politic in law, and in fact to have continuance by this name, style and title in said instrument provided and declared.

By the Court.

EDWIN H. STOWE,
Pres't Judge.

State of Pennsylvania, County of Allegheny. } *sct.*

Recorded in the Office for the Recording of Deeds, &c., in and for said county, on the 20th day of March, A. D. 1880, in Charter Book, Vol. 6, page 277.

Witness my hand and the seal of said office, the day and year aforesaid.

R. J. RICHARDSON,
Recorder.

BY-LAWS.

ARTICLE I.

Regular meetings for the reading of papers and discussion of scientific subjects shall be held on the THIRD TUESDAY OF EACH MONTH.

Special meetings may be called by the President, and shall be called at the request of five members in writing.

Notices of special meetings shall be mailed to each active member, at least one week in advance of said meeting.

Notices of special meetings shall contain a statement of the object for which the meeting is called, and no subject not stated in the notice shall be decided at any special meeting.

ARTICLE II.

SECTION 1. The following order of business shall be observed at the Annual Meeting:

1. Reading of minutes of last Annual Meeting.
2. Report of Treasurer.
3. Report of Secretary.
4. Annual report of the Board of Direction.
5. Reports of special committees.
6. Address of retiring President.
7. Election, and announcement of election of officers.
8. Adjournment.

SEC. 2. The following shall be the order of business for the regular meetings:

1. Reading of minutes of last regular, and of subsequent special meetings.
2. Report of the Board of Direction.
3. Election of new members.
4. Unfinished business.
5. Reports of committees.
6. New business.
7. Miscellaneous announcements, papers, items, notes, or communications.
8. Adjournment.

SEC. 3. In all questions arising at any meeting involving parliamentary rules, those adopted by the Councils of Pittsburgh shall be accepted as authority.

ARTICLE III.

The dues of members shall be Five Dollars per annum, payable in advance, at the annual meeting; *Provided, however*, that all members elected after the first day of July shall pay one-half of said amount, and receive the transactions of the current year.

Any member in arrears for one year or more may, at the discretion of the Board of Direction, be deprived of the privileges of the Society until said arrears have been paid.

ARTICLE IV.

Amendments to the By-Laws must be proposed in writing, by at least three members at one regular meeting, and adopted by a two-thirds vote at a subsequent regular meeting; providing written notice of such amendment be sent to each member with notice of meeting.

LIST OF OFFICERS.

1880.

President, WM. METCALF.

Vice Presidents.

J. J. WILLIAMS, A. GOTTLIEB.

Directors.

THOS. RODD, JOS. L. LOWERY,
EDWARD M. BUTZ, N. M. MCDOWELL.

Treasurer, WM. KENT. *Secretary*, JAS. H. HARLOW.

1881.

President, WM. METCALF.

Vice Presidents.

A. GOTTLIEB, THOS. RODD.

Directors.

JOS. L. LOWERY, N. M. MCDOWELL,
SAMUEL DIESCHER, F. A. PHILLIPS.

Treasurer, A. E. FROST. *Secretary*, JAS. H. HARLOW.

1882.

President, A. GOTTLIEB.

Vice Presidents.

WM. THAW, Jr. THOS. RODD.

Directors.

A. DEMPSTER, SAMUEL DIESCHER,
M. V. SMITH, F. C. PHILLIPS.

Treasurer, A. E. FROST. *Secretary*, J. H. HARLOW.

1883.

President, A. GOTTLIEB.

Vice Presidents.

THOS. RODD, F. C. PHILLIPS.

Directors.

MAX LIVINGSTON, W. MILLER,
J. L. AWL, A. DEMPSTER.

Treasurer, A. E. FROST. *Secretary,* J. H. HARLOW.

1884.

President, WM. MILLER.

Vice Presidents.

F. C. PHILLIPS, THOS. RODD.

Directors.

WM. METCALF, A. DEMPSTER,
S. B. FISHER, J. L. AWL.

Treasurer, A. E. FROST. *Secretary,* J. H. HARLOW.

1885.

President, GEO. H. BROWN.

Vice Presidents.

C. L. STROBEL, F. C. PHILLIPS.

Directors.

WM. MARTIN, WM. METCALF,
WM. THAW, JR. S. B. FISHER.

Treasurer, A. E. FROST. *Secretary,* W. F. ZIMMERMAN.

1886.

President, E. B. TAYLOR.

Vice Presidents.

S. B. FISHER,*

A. DEMPSTER,† C. L. STROBEL.

Directors.

W. L. SCAIFE, WM. MARTIN.

F. C. PHILLIPS, WM. THAW, JR.

Treasurer, A. E. FROST. *Secretary*, S. M. WICKERSHAM.

1887.

President, A. DEMPSTER.

Vice Presidents.

J. A. BRASHEAR, M. J. BECKER.

Directors.

E. B. TAYLOR, W. L. SCAIFE,

A. E. HUNT, F. C. PHILLIPS.

Treasurer, A. E. FROST. *Secretary*, S. M. WICKERSHAM.

1888.

President, A. DEMPSTER.

Vice Presidents.

W. L. SCAIFE, J. A. BRASHEAR.

Directors.

E. B. TAYLOR, T. P. ROBERTS,

A. E. HUNT, CHAS. DAVIS.

Treasurer, A. E. FROST. *Secretary*, S. M. WICKERSHAM.

*Resigned in April. †Elected in April.

LIST OF MEMBERS.

JULY 1st, 1888.

Date of Membership.		
Jan. 6, '80.	Ackenheil, Chas.,	Chief Eng. B. & O. R. R., Elizabeth, N. J.
Mar. 20, '88.	Aikman, Edw. G.,	McConway & Torley Co., 48th and A. V. R. R., Pittsburgh, Pa.
Oct. 20, '85.	Albree, C. B.,	191 Ridge Street, Allegheny, Pa.
Apr. 20, '80.	Amsler, Chas., M. E.,	Mackintosh, Hemphill & Co. Pittsburgh, Pa.
Dec. 16, '84.	Anderson, J. W.,	45 Fremont St., Allegheny, Pa.
Jan. 6, '80.	Armstrong, Edw.,	Supt. Alleg. Water Works, 160 Webster Ave., Allegheny, Pa.
Jan. 6, '80.	Armstrong, H. W.,	Metcalf, Paul & Co., Pittsburgh, Pa.
Jan. 18, '87.	Arms, W. F.,	M. E., R. & P. C. & I. Co., Punxsutawney, Pa.
Feb. 21, '82.	Aull, W. F., C. E.,	Manager Denny Estate, Box 91, Pittsburgh, Pa.
Nov. 21, '82.	Aurentz, F. C. H.,	Eng., Decatur Iron Bridge and Construction Co., Decatur, Ala.
Jan. 6, '80.	Awl, John L.,	Mgr. Monong. Incline Plane, Pittsburgh, Pa.
Sept. 20, '87.	Bailey, Chas.,	Asst. Supt. Pitts. Steel Ctg. Co. Pittsburgh, Pa.

Date of Membership.		
Sept. 16, '84.	Bailey, Jas. M.,	Mfr., Sligo Iron Works, Pittsburgh, Pa.
Jan. 15, '84.	Baker, Chas. H.,	Metcalf, Paul & Co., Verona, Pa.
May 18, '84.	Bakewell, Thos. W.,	Bakewell Building, Pittsburgh, Pa.
June 19, '88.	Bakewell, Wm.,	110 Diamond St., Pittsburgh, Pa.
Apr. 17, '88.	Barbour, Geo. H.,	Perrysville Ave., Allegheny, Pa.
Feb. 17, '80.	Barret, Jonathan,	Hamilton Building, Pittsburgh, Pa.
May 19, '85.	Barnes, Phineas,	Jones & Laughlins, Ltd. Pittsburgh, Pa.
Nov. 21, '82.	Bates, Onward,	C. Engineer, Milwaukee, Wis.
Jan. 6, '80.	Becker, Max. J.,	C. Eng., P., C. & St. L. Ry. Pittsburgh, Pa.
Jan. 20, '85.	Beckfield, Chas.,	Eagle Mill Building, Allegheny, Pa.
Jan. 19, '86.	Bennett, C. M.,	Supt. Eng. C., St. L. & P.R.R. Richmond, Ind.
Dec. 18, '83.	Benney, Jas.,	78 Cedar Ave., Allegheny, Pa.
Jan. 6, '80.	Bigelow, E. M.,	Chf. of Dept. of Public Wks., Pittsburgh, Pa.
Feb. 20, '83.	Bissell, D. S.,	Bissell Block, Pittsburgh, Pa.
Mar. 21, '82.	Blake, F. C.,	Penna. Lead Works, Mansfield Valley, Pa.
Sept. 18, '83.	Blank, Hugo,	Chemist, 77 Fourth Ave., Pittsburgh, Pa.
Mar. 18, '84.	Bole, W. A.,	Supt. Westinghouse Mach. Co. 25th and Liberty Sts., Pittsburgh, Pa.
Jan. 6, '80.	Borntraeger, H. W.,	Union Mill, Pittsburgh, Pa.
Jan. 19, '86.	Bothfield, Chas.,	Keystone Bridge Works, Pittsburgh, Pa.

Date of Membership.		
Apr. 19, '81.	Boyd, Henry A.,	National Tube Works, McKeesport, Pa.
Mar. 18, '84.	Brashear, John A.,	Optician, Observatory Ave., Allegheny, Pa.
Nov. 16, '80.	Bray, Thos. I.,	Mgr. Riverside Iron Works, Wheeling, W. Va.
Apr. 19, '87.	Breen, H.,	Keystone Bridge Co., Pittsburgh, Pa.
Jan. 6, '80.	Brendlinger, P. F.,	C. E., Schuylkill Valley R. R. R. Co., Pottsville, Pa.
May 19, '85.	Bridges, H. R.,	Engineer, Ashville, N. C.
Jan. 19, '86.	Brockett, Alonzo H.,	111 Fourth Ave., Pittsburgh, Pa.
Jan. 6, '80.	Browne, Geo. H.,	Supt. Water Works, Pittsburgh, Pa.
Jan. 6, '80.	Brown, W. R.,	City Engineer's Office, Pittsburgh, Pa.
Apr. 18, '82.	Brunot, H. J.,	Greensburg, Pa.
Jan. 16, '83.	Buchanan, C. P., Jr.,	P., C. & St. L. R. R. Pittsburgh, Pa.
Feb. 9, '86.	Buel, A. W.,	Mt. Vernon Bridge Co. Mt. Vernon, Ohio.
Jan. 18, '87.	Buente, C. F.,	Stone Contractor, Duquesne Way & 10th St., Pittsburgh, Pa.
Jan. 6, '80.	Bullock, W. S.,	Taylor & Bullock, Pittsburgh, Pa.
Sept. 21, '80.	Burgher, Rutherford,	Crescent Steel Works, Pittsburgh, Pa.
Dec. 13, '83.	Burwell, L. C.	246 Superior St., Cleveland, O.
Jan. 6, '80.	Butz, E. M.,	Architect, 112 Federal St., Allegheny, Pa.
Apr. 15, '84.	Cable, D. J.,	Electrician and Mechanician, 77 Fourth Ave., Room 22, Pittsburgh, Pa.
Jan. 19, '86.	Cadman, A. W.,	Brass Manufacturer, Pittsburgh, Pa.

Date of Membership.		
Feb. 9, '86.	Campbell, Harry C.,	Nat. Gas Burners, 6 Ninth St., Pittsburgh, Pa.
Dec. 20, '87.	Campbell, Hugh C.,	Engineer, Allegheny, Pa.
May 23, '82.	Camp, Jas. M.,	Chemist, McClelland House, Uniontown, Pa.
Feb. 20, '83.	Carhart, Danl.,	C. E., Prof. Math. and Eng., Western University, Allegheny, Pa.
May 19, '85.	Carlin, Thos. H.,	Machinist, 186 Lacock St., Allegheny, Pa.
Nov. 18, '84.	Carlin, David,	Mgr. W. G. Price & Co. Iron and Lead Works, 5th Ave. and Price St., Pittsburgh, Pa.
Apr. 20, '80.	Carnegie, Andrew,	Steel, 55 Broadway, New York.
Sept. 18, '83.	Chambers, J. S., Jr.,	C. E., Box 212, Trenton, N. J.
Feb. 17, '80.	Chess, H. B.,	Chess, Cook & Co., Nails and Tacks, Pittsburgh, Pa.
Nov. 21, '82.	Clapp, Geo. H.,	Chemist, 95 & 97 Fifth Ave., Pittsburgh, Pa.
Jan. 18, '88.	Clark, R. N.,	Rustless Iron Co., 32d and Smallman Sts., Pittsburgh, Pa.
Jan. 16, '83.	Clark, Thos. E.,	34 Craig St., Allegheny, Pa.
Oct. 16, '83.	Coffin, Wm.,	Draughtsman, Franklin St., Allegheny, Pa.
Apr. 19, '87.	Colby, J. A.,	33 Singer Building, Pittsburgh, Pa.
Feb. 22, '81.	Cooper, Chas. A.,	Bakewell Building, Pittsburgh, Pa.
Dec. 20, '81.	Cooper, John W.,	Draughtsman, Pitts. Locomotive Works, Allegheny, Pa.
Oct. 22, '85.	Creighton, D. L.,	Kansas City, Mo.
Apr. 15, '84.	Cueto, Jose de,	Union Bridge Co., Athens, Pa.

Date of Membership.		
Sept. 21, '80.	Curry, H. M.,	Lucy Furnace Co., Pittsburgh, Pa.
June 19, '88.	Cunningham, A. C.,	G. W. G. Ferris & Co., Hamilton Building, Pittsburgh, Pa.
Oct. 16, '83.	Dagron, Jas. C.,	Inspector of Bridges, B. & O. R. R., Baltimore, Md.
Dec. 20, '83.	Dame, S. P.,	Chemist, 504 N. Hiland Av., E. E., Pittsburgh, Pa.
May 23, '83.	Danse, L. O.,	Architect, Helena, Montana.
June 19, '88.	Davis, Chas. H.,	G. W. G. Ferris & Co., Hamilton Building, Pittsburgh, Pa.
Jan. 6, '80.	Davis, H. M.,	Draughtsman, 55 Chatham Street, Pittsburgh, Pa.
Jan. 6, '80.	Davis, Chas.,	County Eng., Court House, Pittsburgh, Pa.
Dec. 21, '80.	Davidson, Geo. S.,	60 Fourth Ave., Pittsburgh, Pa.
Jan. 6, '80.	Dempster, Alex.,	C. E., Coal Operator, Stevenson Building, Pittsburgh, Pa.
Mar. 18, '84.	Dickson, Thos. H.,	P. O. Box 672, Pittsburgh, Pa.
Feb. 22, '81.	Dickinson, H. C.,	75 Third Ave., Pittsburgh, Pa.
Jan. 6, '80.	Diescher, Saml.,	M. E., Hamilton Building, Pittsburgh, Pa.
Apr. 19, '81.	Dixon, C. G.,	Contractor, 34 Park Way, Allegheny, Pa.
Nov. 15, '87.	Dobson, Thos. H.,	Engineer, W. P. R. R., Allegheny, Pa.
Apr. 15, '84.	Dravo, H. G.,	Iron Mcht., 413 Wood St., Pittsburgh, Pa.
Jan. 18, '88.	DuBarry, H. B.,	Office Ch. Eng. Pa. Lines, Pittsburgh, Pa.

Date of Membership.		
Jan. 18, '81.	Eckert. E. W.,	C. E., Room 286 Washington Bldg., No. 7 Broadway, New York.
Jan. 6, '80.	Edeburn, Wm. A.,	Eng. and Surveyor, Bakewell Building, Pittsburgh, Pa.
Jan. 6, '80.	Ehlers, Chas.,	City Eng., No. 8 City Hall, Allegheny, Pa.
Feb. 27, '88.	Engle, Geo. W.,	Eng., Gen. Office Penna. Co. Pittsburgh, Pa.
Sept. 19, '82.	Engstrom, F.,	Engineer, Penna. Co., Pittsburgh, Pa.
Feb. 4, '88.	Estrade, E. D.,	Engineer, Chf. Eng. Office, P., C. & St. L. Ry., Pittsburgh, Pa.
Nov. 15, '87.	Euwer, A. H.,	Lumber Merchant, Allegheny, Pa.
Dec. 20, '87.	Felkel, Frank,	335 Main St., Lawrenceville, Pittsburgh, Pa.
Mar. 6, '86.	Ferris, Geo. W. G.,	C. E., Insp. of Iron & Steel, P.O. Box 539, Pittsburgh, Pa.
Apr. 19, '87.	Fielding, J. S., C. E.,	Westinghouse Air Brake Co. Pittsburgh, Pa.
June 16, '85.	Fisher, S. B.,	Engineer, Green Bay, Wisconsin.
Jan. 20, '85.	Fitler, F. K.,	121 Water St., Pittsburgh, Pa.
Jan. 18, '87.	Follansbee, Gilbert,	Supt. Chamber of Com., Pittsburgh, Pa.
Sept. 22, '87.	Fortune, W. W.,	Engineer, Turtle Creek, Pa.
Feb. 21, '82.	Frank, Isaac W.,	Founder, Lewis Foundry Co. Pittsburgh, Pa.
Sept. 19, '82.	Fredericks, J. H.,	Penna. Co., Pittsburgh, Pa.
Jan. 6, '80.	Frost, A. E.,	Prof. of Physics, W. U., 133 North Ave., Allegheny, Pa.

Date of Membership.		
Apr. 17, '88.	Fulton, Louis B.,	Chancery Lane, Pittsburgh, Pa.
Jan. 19, '86.	Geisenheimer, W. A.,	608 Fifth Ave, Pittsburgh, Pa.
Oct. 16, '83.	Glafey, Frederick,	Keystone Bridge Works, Pittsburgh, Pa.
Feb. 17, '80.	Goodyear, S. M.,	Waterbury, Conn.
Jan. 6, '80.	Gottleib, A.,	Room 75, Major's Block, Chicago, Ills.
June 16, '85.	Grant, Horace E.,	119 First Ave., Pittsburgh, Pa.
Sept. 18, '83.	Greiner, Jno. E.,	Asst. Eng. of Bridges and Tests, B. & O. R. R., Baltimore, Md.
Apr. 21, '85.	Griffen, A. L.,	Keystone Bridge Co., Pittsburgh, Pa.
May 19, '85.	Grimes, J. B., M. D.,	327 Carson St., Pittsburgh, Pa.
Sept. 19, '82.	Gwinner, Fred., Jr.,	Contractor, Allegheny, Pa.
Mar. 20, '83.	Hackett, Geo. W.,	Cement, Lime & Terra Cotta, 1009 Liberty St., Pittsburgh, Pa.
Jan. 6, '80.	Hahn, Ignaz,	Engineer and Metallurgist, 97 Fourth Ave., Pittsburgh, Pa.
June 15, '86.	Halstead, J. C.,	C. E., Insp. of Iron and Steel, G. W. G. Ferris & Co., Hamilton Building, Pittsburgh, Pa.
Jan. 6, '80.	Harlow, Jas. H.,	Hydraulic Engineer, 411 Wood St., Pittsburgh, Pa.
Apr. 19, '81.	Harlow, Geo. R.,	Hydraulic Engineer, 411 Wood St., Pittsburgh, Pa.
Dec. 16, '84.	Hay, Saml. W.,	Hussey, Howe & Co., Pittsburgh, Pa.

Date of Membership.		
Jan. 6, '80.	Hemphill, Jas.,	Machinist, Mackintosh, Hemphill & Co., Pittsburgh, Pa.
May 15, '83.	Henning, Gus. C.,	18 Cedar St., New York.
Nov. 14, '85.	Heron, Fred.,	Supt. Phœnix Iron Works, Phœnixville, Pa.
Jan. 19, '86.	Hetzel, Jas.,	60 Fourth Ave., Pittsburgh, Pa.
Apr. 19, '87.	Hibbard, H. D.,	Linden Steel Co., Pittsburgh, Pa.
Apr. 20, '80.	Hoffstot, Frank N.,	Iron Broker, Water St., Pittsburgh, Pa.
Nov. 15, '87.	Hopke, T. M.,	Linden Steel Co., Pittsburgh, Pa.
Jan. 16, '83.	Hunnings, Frank,	Mfrs. Gas Co., Pittsburgh, Pa.
Oct. 18, '81.	Hunt, A. E.,	Chemist, Schmidt & Friday Bldg., Pittsburgh, Pa.
Mar. 17, '85.	Hunter, Jas.,	23 Carson St., S. S., Pittsburgh, Pa.
Oct. 18, '87.	Hyde, J. C.,	Eng., Room 23, Lewis Block, Pittsburgh, Pa.
Feb. 22, '81.	Jennings, B. F.,	Stevenson Building, Pittsburgh, Pa.
Jan. 18, '88.	Johnson, Thos. H.,	Penna. Lines, Tenth and Penn Sts., Pittsburgh, Pa.
Apr. 19, '81.	Jones, B. F.,	Iron Manufacturer, Pittsburgh, Pa.
Apr. 20, '80.	Jones, T. M.,	American Iron Works, Pittsburgh, Pa.
Sept. 21, '80.	Jones, W. R.,	Manager Iron Works, Carnegie Bros. & Co., Pittsburgh, Pa.
Mar. 20, '88.	Jones, W. Larimer,	Jones & Laughlins, Ltd. Pittsburgh, Pa.

Date of Membership.		
Nov. 16, '80.	Kaufman, Gustave,	Supt. Clearfield & New York Short Route R. R., Cresson, Cambria, Co., Pa.
May 18, '80.	Kay, J. C.,	Machinery, Kay Bros. & Co. Water St., Pittsburgh, Pa.
Feb. 17, '85.	Kay, Jas. I.,	Patent Attorney, 96 Diamond St., Pittsburgh, Pa.
June 19, '88.	Keating, A. J.,	Iron Mfr., Zug & Co., Pittsburgh, Pa.
Mar. 17, '85.	Kelley, J. A.,	28th and Smallman Sts., Pittsburgh, Pa.
Jan. 16, '85.	Kelly, J. W.,	Road Master P. & W. Ry. Youngstown, O.
May 18, '86.	Kennedy, Julien,	48 Fifth Ave., Pittsburgh, Pa.
Sept. 19, '82.	Kenyon, L. H.,	Pitts. Locomotive Works, Allegheny, Pa.
June 19, '88.	Kenyon, Edw. H.,	G. W. G. Ferris & Co., Hamilton Building, Pittsburgh, Pa.
Feb. 21, '82.	Kerr, T. B.,	Lawyer, 110 Diamond St., Pittsburgh, Pa.
May 15, '88.	Kettredge, G. W.	Engineer, M. of Way, Pittsburgh, Pa.
June 19, '88.	Kimball, Frank I.,	Mining Engineer, Greensburg, Pa.
Feb. 21, '82.	King, T. M.,	B. & O. R. R., Baltimore, Md.
Mar. 16, '82.	Kirk, Arthur,	Arthur Kirk & Son, Powder and High Explosives, 910 Duquesne Way, Pittsburgh, Pa.
Nov. 15, '87.	Kirkland, A. P.,	Supt. W. P. R. R., Allegheny, Pa.
Apr. 19, '87.	Klages, Geo. W.,	Machinist Foreman, 130 Eleventh St., S. S., Pittsburgh, Pa.

Date of Membership.		
Apr. 19, '87.	Koch, Walter E.,	Supt. Spang's Steel Works, Sharpsburg, Pa.
Jan. 6, '80.	Laing, Geo.,	1004 Penn Ave., Pittsburgh, Pa.
May 15, '83.	Larimer, Geo. F.,	Manager, Westinghouse A. B. Co., Allegheny, Pa.
Feb. 17, '85.	Laub, Herman,	Iron City Bridge Works, Pittsburgh, Pa.
May 19, '85.	Lauder, Geo.,	48 Fifth Ave. Pittsburgh, Pa.
Feb. 21, '82.	Laughlin, F. B.,	Electric Light Carbons, Schmidt & Friday Bldg., Pittsburgh, Pa.
June 19, '88.	Lean, R. B.,	Lean & Blair, Engineers and Contractors, Pittsburgh, Pa.
Jan. 17, '88.	Leech, Louis D.,	44th St. and Center Ave., Pittsburgh, Pa.
Apr. 15, '84.	Leishman, John A.G.,	Lewis Block, Pittsburgh, Pa.
May 16, '80.	Leschorn, Alex.,	M. E., Phœnix Bridge Co. Phœnixville, Pa.
Mar. 16, '80.	Lewis, J. L.,	Lewis Foundry and Machine Co. Ltd. Pittsburgh, Pa.
Apr. 20, '80.	Lewis, W. J.,	Linden Steel Co., Pittsburgh, Pa.
Feb. 21, '82.	Lindenthal, Gustave,	Engineer, Lewis Block, Pittsburgh, Pa.
Sept. 16, '84.	Lloyd, Henry,	Iron Mfr., H. Lloyd, Sons & Co. Pittsburgh, Pa.
May 19, '81.	Lloyd, John W.,	Iron Mfr., H. Lloyd, Sons & Co. Pittsburgh, Pa.
Oct. 19, '80.	Loomis, Geo. P.,	Iron Mfr., Crescent Steel Works, Pittsburgh, Pa.

Date of Membership.		
Feb. 9, '86.	Long, Thos. J.,	Iron Mfr., Morse Bridge Works, Youngstown, O.
Jan. 6, '80.	Lowry, Jos. L.,	Hydraulic Eng., City Hall, Pittsburgh, Pa
Jan. 6, '80.	Macbeth, Geo. A.,	Keystone Flint Glass Co. Pittsburgh, Pa.
Jan. 20, '85.	Mallen, Jas.,	Apollo, Pa.
Apr. 19, '81.	Malone, M. L.,	Engineer, Pittsburgh, Pa.
Jan. 6, '80.	Martin, Wm.,	Resident Eng., Davis Island Dam, P. O. Box 70, Pittsburgh, Pa.
Dec. 18, '83.	Mead, Edwd.,	City Engineer, Nashville, Tenn.
Jan. 6, '80.	Melber, Fred.,	Box 155, Sharpsburg, Pa.
Mar. 20, '88.	Meredith, John R.	
Mar. 20, '88.	Mesta, Geo.,	C. E., Vice Pres. Leechburg Foundry and Machine Co., 130 First Ave., Pittsburgh, Pa.
Jan. 6, '80.	Metcalf, Wm.,	Crescent Steel Works, 49th and R. R. Sts., Pittsburgh, Pa.
Jan. 15, '84.	Meyran, L. A.,	Canonsburg Iron and Steel Co., Germania Bank Bldg. Pittsburgh, Pa.
Sept. 18, '83.	Miles, Geo. K.,	Sec. and Treas. Charlotte Fur. Co. Pittsburgh, Pa.
Feb. 21, '82.	Milholland, J. B.,	Engine Builder, Fifth Ave., Pittsburgh, Pa.
Jan. 6, '80.	Miller, J. R.,	City Engineer, Toledo, O.
Jan. 6, '80.	Miller, Jas.,	Apollo, Pa.
Jan. 6, '80.	Miller, Reuben,	Crescent Steel Works, Pittsburgh, Pa.

Date of Membership.		
Apr. 20, '80.	Miller, Wm.,	Duquesne Forge, Pittsburgh, Pa.
May 19, '85.	Miller, Wilson,	Sec. Pittsburgh Loco. Works, 18 Lincoln Ave., Allegheny, Pa.
Oct. 19, '80.	Milliken, A. C.,	Iron Master, Bennett P. O., Allegheny Co., Pa.
Jan. 20, '85.	Mitchel, G. B.,	Iron Merchant, P.O. Box 862, Pittsburgh, Pa.
Apr. 19, '81.	Moorhead, M. K.,	Moorhead-McCleane Co., Pittsburgh.
Mar. 15, '81.	Morgan, Jas.,	2528 Sarah St., S. S., Pittsburgh, Pa.
Oct. 19, '86.	Morris, G. W.,	Genl. Mngr. The A. French Spring Co., Ltd., Pittsburgh, Pa.
May 15, '83.	Morse, H. C.,	Engineer, Edgemoor, Del.
Apr. 15, '80.	Munro, R.,	Boiler Manufacturer, 23d and Smallman Sts., Pittsburgh, Pa.
Mar. 18, '84.	Murray, A. S.,	108 Penn St., Pittsburgh, Pa.
Jan. 6, '80.	McAdams, D. J.,	Prof. Washington and Jefferson College, Washington, Pa.
Mar. 16, '80.	McCandless, E. V.,	Merchant, Pittsburgh, Pa.
Apr. 20, '86.	McClay, Ralston,	Westinghouse A. B. Co., Allegheny, Pa.
Dec. 18, '83.	McCloy, Wm.,	36 Locust St., Allegheny, Pa.
May 19, '85.	McConnell, John A.,	119 Water St., Pittsburgh, Pa.
Mar. 15, '81.	McCulley, R. L.,	101 Fifth Ave., Pittsburgh, Pa.
Feb. 22, '81.	McCune, John D.,	98 Fourth Ave., Pittsburgh, Pa.
Apr. 18, '87.	McDowell, Jas.,	Optician, Observatory Ave., Allegheny, Pa.

Date of Membership.		
Sept. 21, '80.	McKinney, J. P.,	60 Sheffield St., Allegheny, Pa.
Jan. 16, '83.	McKinney, R. M.,	Elizabeth, Pa.
Mar. 15, '81.	McLennan, Alex.,	56 Second Ave., Pittsburgh, Pa.
Feb. 21, '82.	McMurtry, Geo. G.,	Pittsburgh, Pa.
Feb. 17, '85.	McQuiston, Jas.,	26th and Railroad Sts., Pittsburgh, Pa.
Mar. 15, '81.	McRoberts, J. H.,	400 Grant St., Pittsburgh, Pa.
Apr. 15, '84.	McTighe, Jas J.,	Freeport, Pa.
Jan. 6, '80.	Naegeley, Jno.,	Eng. and Architect, Room 9, Renshaw Bldg., Liberty & 9th Sts., Pittsburgh, Pa.
Jan. 19, '86.	Nevins, Richard, Jr.,	Pittsburgh, Pa.
	Nichols, T. R.,	223 Allegheny Ave., Allegheny, Pa.
Apr. 20, '80.	Nimick, F. B.,	Steel Mfr., Singer, Nimick & Co., Pittsburgh, Pa.
Feb. 21, '82.	Noble, Patrick,	Pacific R. M. Co., 202 Market Street, San Francisco, Cal.
May 19, '85.	Osborn, Frank C.,	C. E., G. W. G. Ferris & Co., Inspector of Iron and Steel for Structural Purposes, Pittsburgh, Pa.
Feb. 20, '83.	Paddock, Jos. H.,	Civil Engineer, Connellsville, Pa.
Mar. 18, '84.	Painter, Park,	Iron Mfr., J. Painter & Sons, Pittsburgh, Pa.
Jan. 6, '80.	Parkin, Chas.,	Crescent Steel Works, Pittsburgh, Pa.
Apr. 15, '84.	Parkin, Walter F.,	136 First Ave., Pittsburgh, Pa.
Feb. 22, '81.	Patterson, Peter,	National Tube Works, McKeesport, Pa.

Date of Membership.		
Nov. 15, '81.	Paul, J. W.,	Verona Tool Works, Seventh Ave. and Liberty St., Pittsburgh, Pa.
Apr. 15, '84.	Paulson, Frank G.,	Hatter, Wood St., Pittsburgh, Pa.
Mar. 15, '87.	Pease, Chas. T.,	Westinghouse Electric Co., Pittsburgh, Pa.
Sept. 18, '83.	Peebles, Andrew,	Architect, Schmidt & Friday Building, Pittsburgh, Pa.
Jan. 6, '81.	Pettit, Robt. E.,	Penna. R. R. Co., Altoona, Pa.
Jan. 20, '80.	Phillips, F. C.,	Prof. of Chemistry, W. U., Pittsburgh, Pa.
Jan. 16, '83.	Phipps, Henry, Jr.,	Carnegie, Phipps & Co. Ltd., Pittsburgh, Pa.
Dec. 20, '81.	Porter, John C.,	Spang Steel and Iron Co., Pittsburgh, Pa.
Jan. 16, '83.	Prentice, W. J.,	Cement, Lime & Terra Cotta, 1009 Liberty St., Pittsburgh, Pa.
Apr. 17, '83.	Price, C. B.,	A. V. R. R., Pittsburgh, Pa.
May 17, '87.	Porter, John E.,	Iron Broker, 413 Wood St., Pittsburgh, Pa.
Jan. 6, '80.	Quincey, W. C.,	Genl. Man. P. & L.E. R. R., Pres. P., McK. & Y.R. R., 77 Fourth Ave., Pittsburgh, Pa.
Mar. 15, '81.	Ramsey, Jos., Jr.,	C. E., Cin., Ham. & Dayton R. R., Cincinnati, Ohio.
Nov. 21, '82.	Rea, Sam.,	Penna. Co., 223 S. Fourth St., Philadelphia, Pa.
Jan. 20, '80.	Reed, Jas.,	Supt. Schuylkill Div. P. R. R., Reading, Pa.
Jan. 20, '80.	Rees, Thos. M.,	Machinist, J. Rees & Sons, Pittsburgh, Pa.
Jan. 6, '80.	Reese, Jacob,	Iron Master, Penn Bldg, Pittsburgh, Pa.

Date of Membership.		
June 19, '88.	Reinmann, A. L.,	Westinghouse Electric Co., Pittsburgh, Pa.
Jan. 20, '85.	Reisinger, Chas.,	1016 Penn Ave., Pittsburgh, Pa.
May 15, '83.	Reno, Geo. E.,	90 Fourth Ave., Pittsburgh, Pa.
Jan. 6, '80.	Rhodes, Joshua,	Penna. Tube Works, Pittsburgh, Pa.
Jan. 6, '80.	Ricketson, John H.,	Founder, 6 Wood St., Pittsburgh, Pa.
Apr. 19, '87.	Rider, Percy S.,	6 Ninth St., Pittsburgh, Pa.
Jan. 17, '88.	Robbins, F. L.,	Penn Building, Pittsburgh, Pa.
Nov. 24, '85.	Roberts, Rd. A.,	Mfrs. Nat. Gas Co., Pittsburgh, Pa.
Jan. 6, '80.	Roberts, Thos. P.,	C. Engineer, 53 Beech St., Allegheny, Pa.
Jan. 6, '80.	Rodd, Thos.,	Penna. Co., Pittsburgh, Pa.
Jan. 17, '88.	Rund, Edwin F.,	706 Penn Ave., Pittsburgh, Pa.
Apr. 15, '84.	Scaife, O. P.,	Wm. B. Scaife & Sons, Structural Iron Works, 119 First Ave., Pittsburgh, Pa.
Mar. 20, '83.	Scaife, W. Lucien,	Scaife Foundry and Mach. Co., 28th and Smallman Streets, Pittsburgh, Pa.
Sept. 20, '87.	Scaife, W. Marcelin,	336 Ridge Ave., Allegheny, Pa.
Feb. 21, '82.	Schellenberg, F. Z.,	Irwin Station, West. Co., Pa.
Jan. 6, '80.	Schinneller, Jacob,	M. E., Room 31, McClintock Block, Pittsburgh, Pa.
Feb. 17, '85.	Schmid, Alb.,	Supt. Westinghouse Elec. Co., Pittsburgh, Pa.
May 15, '83.	Schook, Levi,	Short and Water Sts., Pittsburgh, Pa.
May 15, '83.	Schuler, Adolf,	Dra'tsman, 46th and Davidson Sts., Pittsburgh, Pa.

Date of Membership.		
Jan. 6, '80.	Schultz, A. L.,	Hiland Ave., E. E., Pittsburgh, Pa.
Sept. 19, '82.	Schultz, C. J.,	Iron City Bridge Works, Pittsburgh, Pa.
Feb. 15, '87.	Schultz, R. S.,	Lock Box 232, Pittsburgh, Pa.
Jan. 16, '83.	Schwanecke, H. A.,	C. E., Bissell Block, Pittsburgh, Pa.
Nov. 15, '81.	Schwartz, F. H.,	5000 Liberty St., Pittsburgh, Pa.
Mar. 18, '84.	Schwartz, J. E.,	61 Fourth Ave., Pittsburgh, Pa.
May 23, '82.	Scott, Thos. S.,	Pitts. Locomotive Works, Allegheny, Pa.
Jan. 16, '83.	Scovell, Minor,	Engineer and Contractor, Nashville, Tenn.
Jan. 16, '83.	Seaver, J. W.,	79 Fremont St., Allegheny, Pa.
Apr. 19, '87.	Seymour, John E.,	Homestead, Pa.
May 19, '85.	Shelton, Thos.,	National Tube Works, McKeesport, Pa.
Nov. 18, '84.	Shepler, Cassius R.,	Banger & Natchez, S. S., Pittsburgh, Pa.
Sept. 19, '82.	Sherzer, Wm.,	C. Eng., 209 Home Ins. Bldg., Chicago, Ills.
Nov. 24, '85.	Shultz, O. G.,	McKee's Rocks P. O., Pa.
Jan. 6, '80.	Siebeneck, Jos. G.,	Chronicle Telegraph Office, Pittsburgh, Pa.
Dec. 20, '87.	Simpson, Jos. H.,	Carnegie, Phipps & Co. Ltd., Pittsburgh, Pa.
Sept. 21, '80.	Singer, Harton G.,	83 Water St, Pittsburgh, Pa.
Sept. 21, '80.	Singer, W. H.,	Singer, Nimick & Co., Pittsburgh, Pa.
Jan. 6, '80.	Slataper, Felician,	Chief Eng. Penna. Co., Pittsburgh, Pa.
Mar. 15, '81.	Smith, F. B.,	La Belle Steel Works, Pittsburgh, Pa.

Date of Membership.		
Oct. 18, '87.	Smith, John W.,	159 River Ave., Allegheny, Pa.
Feb. 17, '80.	Snyder, Antes,	Eng. Right of Way, P.R. R., Blairsville, Pa.
Apr. 15, '84.	Snyder, H. P.,	Lewis Block, Pittsburgh, Pa.
Jan. 18, '88.	Speer, B.,	Prof. of Physics, Pitts. High School, Pittsburgh, Pa.
Feb. 17, '80.	Sprague, H. N.,	Porter & Co., Loco. Works, Pittsburgh, Pa.
Jan. 6, '80.	Springer, Jos. S.,	Hamilton, Ohio.
May 19, '81.	Stafford, C. E.,	Shoenberger & Co., Pittsburgh, Pa.
May 19, '83.	Stevenson, David A.,	Civil Engineer, Room 6, Union Station, Pittsburgh, Pa.
Jan. 19, '86.	Stevenson, W. S.,	Philadelphia Co., Roup St., Pittsburgh, Pa.
Nov. 21, '82.	Stewart, Geo. R.,	Gas Engineer, Lewis Block, Pittsburgh, Pa.
Nov. 21, '82.	Stewart, D. A.,	48 Fifth Ave., Pittsburgh, Pa.
Oct. 19, '86.	Stewart, J. H.,	48 Fifth Ave., Pittsburgh, Pa.
Jan. 6, '80.	Stillburg, Jos. H.,	Architect, 20 Fifth Ave., Pittsburgh, Pa.
Mar. 18, '84.	Stouffer, B. W.,	Clinton Iron Works, Lock Box 379, Pittsburgh, Pa.
Jan. 6, '80.	Strobel, C. L.,	M. E., 210 Home Ins. Bldg., Chicago, Ills.
Oct. 19, '80.	Sutton, Thos.,	Pittsburgh, Pa.
Feb. 20, '83.	Swan, Robt.,	Civil Engineer, Allegheny Ave., Allegheny, Pa.

Date of Membership.		
Apr. 19, '87.	Swenson, Emil,	Keystone Bridge Works, Pittsburgh, Pa.
Feb. 19, '84.	Taylor, B. H.,	C. E., Rankin Station, Allegheny Co., Pa.
Apr. 20, '80.	Taylor, E. B.,	Genl. Supt. Penna. Co., Pittsburgh, Pa.
May 18, '86.	Tener, Geo. E.,	Oliver Bros. & Phillips, Pittsburgh, Pa.
Mar. 16, '80.	Thacher, Edwin,	Bridge Construction Co., Decatur, Ala.
Dec. 21, '81.	Thaw, Wm., Jr.,	Hecla Coke Co., 21 Lincoln Ave., Allegheny, Pa.
Dec. 21, '81.	Thomas, Alex.,	Sewickley, Pa.
Apr. 21, '85.	Todd, Jas.,	Chemist, 127 North Ave., Allegheny, Pa.
Nov. 24, '85.	Totten, Sidney H.,	Pittsburgh, Pa.
Dec. 20, '87.	Travelli, Chas. J.,	Chemist, 333 42d St., Pittsburgh, Pa.
Jan. 6, '80.	Trimble, Robt.,	Penna. Co., Pittsburgh, Pa.
Feb. 22, '81.	Utley, Edwd. H.,	A. V. R. R., Pittsburgh, Pa.
May 19, '85.	Verner, M. S.,	Supt. Citizens Traction Co., 939 Penn Ave., Pittsburgh, Pa.
Dec. 20, '87.	Verner, Henry W.,	Shiffler Bridge Works, Pittsburgh, Pa.
Apr. 18, '82.	Wainwright, J.,	C. E., 111 Fourth Ave., Pittsburgh, Pa.
Apr. 19, '87.	Wainwright, J. R.,	P. O. Box 264, Pittsburgh, Pa.
Jan. 6, '80.	Walker, J. W.,	47th St. and A. V. R. R., Pittsburgh, Pa.
Oct. 20, '85.	Walker, Arthur,	53 Main St., Zanesville, Ohio.
Jan. 16, '83.	Warden, C. F.,	Greensburg, Pa.

Date of Membership.		
Nov. 20, '85.	Wassell, E. D.,	Cleveland Steel Co., Garden St. & C. & P. R.R., Cleveland, Ohio.
Jan. 6, '80.	Weeks, Jos. D.,	Editor Amer. Manufacturer, Box 1547, Pittsburgh, Pa.
Apr. 19, '87.	Weiskopf, Saml. C.,	Box 732, Pittsburgh, Pa.
Dec. 20, '87.	Welden, Lewis C.,	Asst. Eng., Union Station, Pittsburgh, Pa.
June 21, '87.	Werner, Emerich A.,	Ch. Eng. Office L. & N. R. R., Louisville, Ky.
Feb. 21, '82.	Westerman, Thos.,	Verona Tool Works, Verona, Pa.
Feb. 20, '88.	White, H.,	La Belle Steel Works, Allegheny, Pa.
May 15, '83.	White, T. S.,	Penna. Bridge Works, Beaver Falls, Pa.
Jan. 6, '80.	Whittaker, Lee,	39 Sturgeon St., Pittsburgh, Pa.
May 18, '80.	Wickersham, S. M.,	C. Eng., Pittsburgh, Pa.
Oct. 19, '80.	Wickersham, Thos.,	Mill Mgr., Park Bros. & Co., Pittsburgh, Pa.
May 18, '86.	Wierman, Victor,	Eng. Pgh. Div. P. R. R., Pittsburgh, Pa.
Feb. 17, '80.	Wightman, D. A.,	Supt. Pittsburgh Loco. Wrks, Box 76, Allegheny, Pa.
June 16, '85.	Wightman, John R.,	Glass Manufacturer, 53 Fremont St., Allegheny, Pa.
Jan. 6, '80.	Wilcox, John F.,	J. P. Witherow, Lewis Block, Pittsburgh, Pa.
May 15, '87.	Wilkins, W. G.,	C. E., 23 Lincoln Ave., Allegheny, Pa.
Feb. 17, '80.	Wilson, Jno. T.,	Lewis Block, Pittsburgh, Pa.
Jan. 19, '86.	Wilson, Howard M.,	Founder, Craig St., Pittsburgh, Pa.

Date of Membership.		
Jan. 18, '88.	Wilson, F. T.,	Jersey Shore, Lycoming Co., Pa.
Jan. 18, '88.	Wilson, W. R.,	Mining Eng., Mansfield Valley, Pa.
Feb. 20, '88.	Winn, Isaac,	National Rolling Mill, McKeesport, Pa.
Jan. 6, '80.	Witherow, J. P.,	Eng. and Contractor, Lewis Block, Pittsburgh, Pa.
Jan. 15, '84.	Wood, B. L., Jr.,	Coal Operator, 89 Fourth Ave., Pittsburgh, Pa.
Sept. 21, '80.	Wood, R. G.,	Iron Mills, McKeesport, Pa.
Jan. 18, '88.	Wood, Jos.,	Genl. Supt. Transportation Pa. Lines, Pittsburgh, Pa.
Jan. 18, '88.	Woods, Leonard G.,	East End Hotel, Pittsburgh, Pa.
Mar. 20, '82.	Yeatman, Morgan E.,	Bridge Engineer, Room 23, No. 111 Fourth Ave., Pittsburgh, Pa.
Jan. 6, '80.	Zimmerman, W. F.,	Fuel Gas & Elect. Eng. Co., Penn Building, Pittsburgh, Pa.

CORRESPONDENTS.

Society of Arts,	Boston, Mass.
Massachusetts Institute of Technology, Department of Civil Engineering,	Boston, Mass.
Boston Soc. of Engineers,	City Hall, Boston, Mass.
Brinsmade, D. S., Sec. Conn. Assoc. of Civil Engineers and Surveyors,	Birmingham, Conn.
State Association of Engineers,	Norwich, Conn.
American Scientific Society,	219 River St., Troy, N. Y.
Sibley College,	Cornell University, Ithaca, N. Y.
American Society of Civil Engineers,	127 E. 23d St., New York.
Amer. Society of Mechanical Engineers,	280 Broadway, New York.
American Inst. of Mining Engineers,	Lock Box 223, New York.
Journal of Association of Engineering Societies,	18 Chambers St., New York.
Railroad and Engineering Journal,	46 Broadway, New York.
Tichnischer Verein,	210 E. Fifth St., New York.

Library of Second Geological Survey of Pennsylvania,
907 Walnut St.,
Philadelphia, Pa.

Franklin Institute, 18 S. Seventh St.,
Philadelphia, Pa.

Engineers' Club of Philadelphia, 1122 Girard St.,
Philadelphia, Pa.

Tichnischer Verein, 106 Randolph St.,
Chicago, Ills.

Railway Review, Chicago, Ills.

American Engineer, Chicago, Ills.

Western Society of Engineers, Home Building,
Chicago, Ills.

Civil Engineers' Club of Cleveland, Cleveland, Ohio.

Prof. C. N. Brown,
Sec. Ohio Society of S. and C. Engineers,
Columbus, Ohio.

Association of County Engineers, Remington, Ind.

Engineers' Club of St. Louis, St. Louis, Mo.

Engineers' Club, Kansas City, Mo.

E. S. Cunningham, Columbia,
Boone Co., Mo.

B. Thompson, Box 430,
Chattanooga, Tenn.

J. M. Whitman, Arkansas Industrial University,
Fayetteville, Ark.

The Practical Mechanic, Worcester, Mass.

Liverpool Engineering Society, Colquitt St.,
Liverpool, England.

Iron and Steel Institute, Lombard St.,
London, E. C.

Journal of Society of Arts, John St., Adelphi, London, W. C.

Institution of C. E., 25 Great George St., Westminster, London, S. W.

Society of Civil Engineers, Westminster Chambers, London, S. W.

London Patent Office, London, England.

Swedish Society of C. E. Stockholm, Sweden.

Norsk Tiknisk Tideskrift, Christiania, Norway.

Associadad dos Engenheiros Civis Portuguezos, Lisboa, Portuguezos.

Sociadad Cientifica Argentina, Buenos Aires, S. A.

Club de Engenharia, Rio de Janeiro, Brazil, S. A.

Henry A. Gordon, Inspecting Engineer, Wellington, New Zealand.

Annales des Mines, Paris, France.

E. Ingeniero Civil, 424 Corrientes, Buenos Aires, Argentine Republic, S. A.

PROCEEDINGS

OF

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

PITTSBURG, PA.

VOL. V.

1889.

THE NEW YORK
PUBLIC LIBRARY
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ASTOR, LENOX AND
TILDEN FOUNDATIONS.
1898.

THE ASTOR LIBRARY.
NY

CHARTER.

To the Court of Common Pleas No. 1, of Allegheny County, Pennsylvania:

We, the subscribers hereto, citizens of the Commonwealth of Pennsylvania, desirous of acquiring and enjoying the powers and immunities of a Corporation, or a body politic in law, do hereby associate ourselves under the articles, conditions and for the objects, and in the name, style and title herein set forth.

ARTICLE I.—This corporation shall be styled and named and bear the title of "ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA."

ART. II.—The object of this corporation shall be the advancement of engineering in its several branches, the professional improvement of its members, and the encouragement of social intercourse among men of practical science.

ART. III.—Among the means to be employed for attaining these ends shall be periodical meetings for the discussion of scientific subjects and social intercourse, the reading of professional papers, and excursions to examine objects of engineering interest.

ART. IV.—Civil, mechanical and mining engineers, geologists, architects, managers and superintendents of railroads, mills and manufactories, and other persons engaged in scientific and mechanical pursuits pertaining to engineering, shall be eligible to membership in this corporation.

ART. V.—There shall be two classes of members, active and honorary. Active members shall be persons who are actively engaged in any pursuit above specified, and who will participate in promoting the interests of this Society, attend its meetings, present papers and vote at elections. Honorary members shall be persons who shall have attained eminence in any of the professions or departments of knowledge or labor mentioned in Article IV. hereof.

ART. VI.—Each person desirous of becoming a member shall be proposed by at least two members, and referred to the Board of Direction, and, when favorably reported, shall be elected by ballot at a regular meeting, upon receiving a majority of the votes cast, and shall become a member on the payment of his first dues, provided the same are paid within three months of his election. Honorary members shall be elected by a unanimous vote.

ART. VII.—The name of any member may be stricken from the list of members, upon its being so ordered by the Board of Direction, and by a vote of three-fourths of the members of this corporation present at any annual meeting; due notice, however, having first been given to said member of such action.

ART. VIII.—The officers of this corporation shall be a President, two Vice-Presidents, a Secretary, a Treasurer and four Directors. The President, one Vice-President, Secretary, Treasurer and two Directors shall be elected annually by ballot, by a majority of the votes cast at the annual meeting, and shall hold their offices until their successors are elected.

The President, Vice-Presidents and Directors shall be eligible to but one re-election in succession. The offices of Secretary and Treasurer may be held by one person.

The President, and in his absence the senior Vice-President present, shall preside, and in case of their absence a President *pro tempore* shall be chosen.

ART. IX.—The Board of Direction shall be composed of the President, two Vice-Presidents and the Directors, elected by the members. They shall have the general management of the affairs of the corporation, shall hold monthly meetings at such times as they shall fix, and special meetings, when called for by the President or any two members of the Board of Direction, and shall report their transactions at each regular meeting.

They shall have power to fill vacancies in their own body, and the persons by them chosen shall continue in office until a successor is chosen, and a special election therefor to fill the office and term made vacant may be had at any regular meeting.

ART. X.—This corporation may make By-Laws not inconsistent herewith, nor with the laws of this Commonwealth.

WM. METCALF,
A. GOTTLIEB,
THOS. RODD,
E. M. BUTZ,
N. M. McDOWELL,
WM. KENT,
J. H. HARLOW.

I hereby certify that I have examined the foregoing articles of Association of the Engineers' Society of Western Pennsylvania, and am of opinion that the objects, articles and conditions therein contained are lawful and not injurious to the community, and within the proper power of the Court of Common Pleas to confirm as an incorporation, under the laws of this Commonwealth.

M. A. WOODWARD,
Solicitor for Applicants.

In matter of the incorporation of the Engineers' Society of Western Pennsylvania. } Common Pleas of Allegheny County.

And now, to wit, this 21st day of February, 1880, the foregoing articles for the incorporation of the Engineers' Society of Western Pennsylvania being presented in open court, and perused and examined, and the objects, articles and conditions appearing lawful, and not injurious to the community, it is directed that the same be filed in the prothonotary's office of this court, and that notice thereof be inserted in the Pittsburg *Legal Journal and Commercial Gazette*, of this county, for three weeks, as required by law.

By the Court,
EDWIN H. STOWE, *P. J.*

In the matter of the incorporation of the Engineers' Society of Western Pennsylvania.

And now, to wit, March 20, 1880, the articles of incorporation of the Engineers' Society of Western Pennsylvania having been, February 21, 1888, filed in the office of the prothonotary of this court, and due notice by publication in the Pittsburg *Legal Journal and Commercial Gazette*, a daily newspaper of this county, made conformatory to law, and no exceptions being filed thereto; Therefore, on motion of M. A. Woodward, it is declared and decreed that the persons so associated under said articles shall, according to the said articles, and the conditions in said instrument set forth and contained, become and be a corporation or body politic in law. And it is further ordered and directed that said charter of incorporation shall be recorded in the office of recording deeds in said county, and on being so recorded the persons so associated, or meaning to associate, shall, according to the articles, objects and conditions in said instrument set forth, become and be a corporation or body politic in law, and in fact to have continuance by this name, style and title in said instrument provided and declared.

By the Court,
EDWIN H. STOWE, *P. J.*

State of Pennsylvania, County of Allegheny. } *sct.*

Recorded in the office for the recording of deeds, etc., in and for said county, on the 20th day of March, A.D. 1880, in Charter Book, Vol. 6, page 277.

Witness my hand and the seal of said office, the day and year aforesaid.

R. J. RICHARDSON, *Recorder.*

BY-LAWS.

ARTICLE I.

Regular meetings for the reading of papers and discussion of scientific subjects shall be held on the THIRD TUESDAY OF EACH MONTH.

Special meetings may be called by the President, and shall be called at the request of five members in writing.

Notices of special meetings shall be mailed to each active member, at least one week in advance of said meeting.

Notices of special meetings shall contain a statement of the object for which the meeting is called, and no subject not stated in the notice shall be decided at any special meeting.

ARTICLE II.

SECTION 1. The following order of business shall be observed at the annual meeting:

1. Reading of minutes of last annual meeting.
2. Report of Treasurer.
3. Report of Secretary.
4. Annual report of the Board of Direction.
5. Reports of special committees.
6. Address of retiring President.
7. Election, and announcement of election of officers.
8. Adjournment.

SEC. 2. The following shall be the order of business for the regular meetings:

1. Reading of minutes of last regular, and of subsequent special meetings.
2. Report of the Board of Direction.
3. Election of new members.
4. Unfinished business.
5. Reports of committees.
6. New Business.
7. Miscellaneous announcements, papers, items, notes or communications.
8. Adjournment.

SEC. 3. In all questions arising at any meeting involving parliamentary rules, those adopted by the councils of Pittsburg shall be accepted as authority.

ARTICLE III.

The dues of members shall be five dollars per annum, payable in advance, at the annual meeting; *Provided, however*, that all members elected after the first day of July shall pay one-half of said amount, and receive the TRANSACTIONS of the current year.

Any member in arrears for one year or more may, at the discretion of the Board of Direction, be deprived of the privileges of the Society until said arrears have been paid.

ARTICLE IV.

Amendments to the By-Laws must be proposed in writing, by at least three members at one regular meeting, and adopted by a two-thirds vote at a subsequent regular meeting; providing written notice of such amendment be sent to each member with notice of meeting.

CONTENTS.

OFFICERS FOR 1889.

PRESIDENT,

JOHN A. BRASHEAR, Observatory Avenue, Allegheny, Pa.

VICE-PRESIDENTS,

One Year.—W. L. SCAIFE, 28th and Smallman Streets, Pittsburg, Pa.

Two Years.—A. E. HUNT, 98 Fourth Avenue, Pittsburg, Pa.

DIRECTORS,

One Year.—T. P. ROBERTS, 53 Beech Street, Allegheny, Pa.

C. DAVIS, Court House, Pittsburg, Pa.

Two Years.—WM. METCALF, Crescent Steel Works.

MAX. J. BECKER, C. Eng., P., C. & St. L. Ry., Pittsburg, Pa.

SECRETARY,

S. M. WICKERSHAM, Pittsburg, Pa.

TREASURER,

A. E. FROST, 133 North Avenue, Allegheny, Pa.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

This Society does not hold itself responsible for the opinions of its members.

NINTH ANNUAL MEETING.

PITTSBURG, JANUARY 22D, 1889.

SOCIETY met at 8 o'clock P.M. at their rooms, Penn Building. President A. Dempster in the chair.

Vice-President W. L. Scaife, Directors A. E. Hunt, E. B. Taylor, T. P. Roberts, Charles Davis, and 44 members being present.

The minutes of the last annual meeting were read and approved.

A. E. Frost, Treasurer, then read his report, viz.:

REPORT OF TREASURER ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA FOR THE YEAR ENDING JANUARY 15TH, 1889.

Receipts.

January 17th, 1888, balance, ...	$161 69
Dues from 3 members to January, 1885, . . .	15 00
" " 4 members to January, 1886, . . .	20 00
" " 7 members to January, 1887, . . .	35 00
" " 16 members to January, 1888, . .	80 00
" " 6 members to January, 1888 (one-half year), ...	15 00
" " 248 members to January, 1889, . .	1240 00
" " 11 members to January, 1889 (one-half year), ...	27 50
" " 3 members to January, 1890, . . .	15 00
Other back dues, ...	9 50
Publications sold, ...	1 50
Lecture tickets (late return), ...	2 00
Total, ...	$1622 19

Expenditures.

Printing,	$501 75
Rent,	268 00
Salary of Secretary,	200 00
Postage and other office expenses,	140 65
Binding,	105 08
Periodicals, English and American,	79 80
Periodicals, German,	49 49
Stenographer,	65 00
Commissions on collections,	11 08
Permanent improvements (cases, etc.),	69 50
Insurance,	45 60
Extra labor in arranging library,	25 00
Dictionary,	11 00
Total,	$1571 95
Balance in hands of Treasurer,	50 24
	$1622 19

Respectfully submitted,

A. E. Frost,
Treasurer.

Pittsburg, January 22d, 1889.

S. M. Wickersham, secretary, presented the following:

Annual Report of the Secretary of the Engineers' Society of Western Pennsylvania.

Pittsburg, January 22d, 1889.

On the 17th day of January, 1888, the number of names on our roll of members was 330. During the year there were admitted 42, aggregating 372. During the same time we lost by death 5; by resignation, 25; leaving on the rolls 342.

Ten regular meetings were held during the year.

January 17th. The eighth annual meeting; present, 50 members. Mr. T. I. Bray read a paper on "Welded Steel Tubes."

February 21st. There were present 100 members and visitors. Mr. R. McK. Loyd read a paper on "Electric Railroads."

March 20th. There were present 71 members and 4 visitors. Mr. F. C. Blake read a paper on "Electrotype Separation of Gold and Silver."

April 17th. There were present 61 members and 4 visitors. Mr. Phineas Barnes read a paper on "The Use of Aluminium Alloys in the Steel Manufacture."

May 16th. There were present 46 members. W. F. Koch read a paper on "Fifteen Years' Experience in Open-Hearth Steel."

June 19th. There were present 21 members. The evening was occupied with a discussion of Mr. Koch's paper on "Open-Hearth Steel."

September 19th. There were present 30 members. Mr. E. G. Aikman read a paper on "The Janny Coupler."

October 16th. There were present 41 members. Thomas P. Roberts read a paper on "The Railroad Situation in Pittsburg in Reference to its Approaches."

November 20th. There were present 65 members. John A. Brashear gave a talk on "Astronomical Engineering in Europe."

December 18th. There were present 39 members and visitors. J. E. Greiner's paper was read on "B. & O. Train Sheds in Pittsburg."

The ten regular meetings in the year were attended by 524 members and visitors, averaging to each meeting 52.4; being a larger attendance than in the previous year by 175 members in the aggregate, or an average of 17.5 to each meeting.

F. C. Phillips, Library Committee, reported, viz.:

MR. PRESIDENT, ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

SIR: On behalf of the Library Committee, I have to present the following report:

According to the catalogue issued in 1883 the library contained books and pamphlets, 409, periodicals 63, comprising 339 volumes. The supplementary catalogue recently prepared by the Library

Committee shows that since 1883 there have been added, books and pamphlets, 210; periodicals, 15. Of the 210 works received, 127 were Government documents, including the scientific publications of the Department of Education, Engineer Department U.S.A., the Signal Service, the 10th Census, and the publications of the Allegheny Observatory.

According to the Librarian's register the total number of visitors to the library during the year was 766, or an average of 2.3 daily. We think it may be stated that the demand has been at all times mainly for the periodical literature with which the reading-room is so well supplied.

It has been our effort to have all journals bound as soon as each volume is completed.

The drawer catalogue is finished.

A box has been placed in a conspicuous position, and a request posted that members would deposit the names of books which they recommend the Society to purchase. Two responses have so far been received. Whether this result is due to excessive modesty on the part of members, or to a lack of confidence in the liberality of the authorities, we are unable to state. Two new book-cases have been added. The importance of securing additional standard works and scientific periodicals needs no comment, and we recommend that as early as possible an appropriation be made for enlarging the library.

FRANCIS C. PHILLIPS,
Chairman.

Report of the Board of Directors ordering the names of 15 delinquent members to be stricken from the list of members was approved by a rising unanimous vote.

The Board of Directors recommended the following for membership: W. W. Shaw, A. G. Shaw, H. E. Hunt, G. H. Baxter, and H. P. De Puy, and they were balloted for and admitted as members.

Verbal reports were made from several of the special committees; after which President Dempster made the following address:

FELLOW-MEMBERS OF THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA:

Another year's transactions of our Society have been placed on record, and another annual page of its history has been written in lines of encouragement to every one interested in the progress of *our* Society.

The report of the Secretary shows a decided improvement in the attendance during the year; and the hope entertained and expressed to you one year ago has been fully realized, and much satisfaction is derived from the review and comparison of the past year with those preceding. The "Program Committee" deserves special mention and credit for the efficiency and success in having papers prepared for every meeting, and the members who have thus interested themselves in their preparation deserve the thanks of their fellow-members, and it is hoped that their example, in thus providing for the monthly entertainment, will have such influence as to prompt many more members to follow the example thus set before them. A marked improvement has been shown in the promptness that has characterized the discussions of the subjects presented in the papers, yet withal a greater degree of interest may be attained if every member of the Society would feel that he is an integral part thereof and a factor in accomplishing results, and so feeling occupy his proper place in the column of figures that constitute the value of our proceedings. You will please pardon me for urging upon all the necessity to lay aside diffidence and stiff formality, and engage in the discussions with an earnest desire to impart or elicit instruction, as such adds materially to the general interest of all.

How to increase the active working list is a matter of no small importance as an element of success in the history of our Society, and one that should receive attention. All members are theoretically on the active list, but a large number practically occupy an honorary position, and cannot be expected to contribute in papers and regular attendance. The fact that they show an interest in the welfare of the Society by the payment of dues is of itself encouraging, and should be taken as a sincere token of their good will. By a little effort amongst this class some might be trans-

ferred to the working class, very much to the benefit of the Society, as their knowledge, observation and experience would be quite an addition to the general fund of information drawn from some of the members for the benefit of all. If they could be influenced to attend the meetings I have no doubt that the Chair will educe from them something useful, interesting, and practical.

How to stir up the zeal and interest of the younger members of the Society is also a problem that presses itself upon us for solution. How to get them to apply the vigor and enthusiasm of youth and the force of brain to the lever of action, and thereby develop the mental energy that is now stored up as a latent power that will add zest to our proceedings, is well worthy of consideration; as young men are the hope of the country in Church, and State, and Forum, so are they likewise in all that pertains to the development of useful and scientific knowledge. They should be encouraged by the older to participate in all our proceedings, and be made to feel that they too are efficient factors in extending the influence and increasing the benefits of our Society both to themselves and others. I know that the greatest difficulty in the accomplishment of this lies in the fact of their own modesty and backwardness to appear as peers of older men; but this should not be. Many cases are on record where the junior has shown himself the superior of the senior, and demonstrated the advancement that has been made along the lines of knowledge, and the young man of to-day is by the superiority of his advantages fully abreast of him who has attained the seniority of years, and, as one of the "older men," I urge upon all young men to resolve and act according to ability and opportunity, and you will find all the encouragement that you desire.

How to extend the lines of the influence of our Society for good throughout our community is also deserving of candid consideration. Our Society should be as light set upon a hill, radiating its beams along the avenues of practical requirement and useful application. I fear that some of our members take too limited a view of the aim and scope of our Society, and by so doing cause others to do the same. This has been particularly manifested by the expressions of a very few individuals who became members

with the sole object in view of advancing their own individual pecuniary interests, and not having aught else to actuate them, they did not achieve the benefits they had hoped for, and consequently dwindled into the obscurity that always shadows those who have no higher motive. Man does not live for himself alone, and he whose actions are dwarfed by such narrow considerations misses the golden opportunities afforded along the avenue of life's pursuits, and fails to reach the standard of true and noble manhood. I am glad to say we have had but few of that class. It is true that there is a chord of selfishness running through the composition of every man, but there is also one of philanthropy that draws him along the lines of usefulness, not only to himself, but to his fellows; and he who can make the former secondary to the latter exhibits the highest type of manhood. And whether in social or other circles that merge in the great cycle of life's accomplishments his motive power is always applied to impel him forward in the right direction, and the wheels of action always "keep to the rails" that guide them to the highest goal of human attainment.

If each member could be fully impressed with the idea that our Society could be made a means of accomplishing a good work, not only for its members, but for the community as well, and, being so impressed, work up to the full measure of opportunity, and we should lay the lines of our action more energetically in that direction, our influence would be more felt throughout the cities of Pittsburg and Allegheny, and our Society would occupy a more prominent position in the estimation of the people, and place the premium of appreciation upon our efforts.

I do not think we should be content to radiate the knowledge and information contained in the papers and proceedings of our Society through the individual spheres of its membership, but should endeavor to supplement such instruction by others in a wider range for the benefit of the many who do not belong to our Society, but who are the hands and mechanical appliances that constitute the bone, nerve and sinew of our workshops, our mills and foundries.

Our Society could institute and conduct a course of lectures on

scientific and practical subjects, and procure able and eloquent masters who would clothe the technical abstruseness of the highest and most advanced subjects in the attractive robes of plain and instructive diction; that would prove popular and beneficial, not only to the artisan and mechanic, but to the proprietors of the different establishments in which they work. I have no doubt that there are many young men, and old too, who would be glad of the opportunity of thus improving themselves, adding to their usefulness and enhancing their chances of promotion in the lines of their specialties. History is thickly dotted with the examples of many men whose names are engraven in the niches of time, who have made themselves a name and place amongst those who have wrested from nature's arcana the legitimate fruits of labor and genius and given them to the world for the benefit of humanity, and did so by the personal application of mental power and mechanical skill after they had attained to the years of their majority; and if the biographies of many of Pittsburg's substantial and enterprising manufacturers were written to-day they would exhibit the fact in colors clear and distinct.

The matter is worthy of a fair, candid and energetic trial, and I hope that the effort will be made ere the Society is another year older. Not only would the benefits be generally diffused, but they would also contribute to the prosperity of the Society.

Another means of extending our influence, and exciting a greater degree of interest in our proceedings by those not members, would be the consideration and discussion of such subjects as would be of *general* interest. I believe it is the legitimate province of our Society to turn on whatever light we can command on any and all subjects in the line of our profession, especially those in which the public at large are interested, and from a purely professional and unbiassed standpoint extend the benefits of whatever knowledge we may possess to those who have "to foot the bills." Let me illustrate my meaning by an example that I think is worthy of imitation in all such cases. When the competing architects submitted their plans for the "Court House" the County Commissioners, with commendable forethought and in the cultivation of a desire to get the best plan that could be devised, placed the

plans on exhibition for the inspection of all, and inviting such suggestions and criticisms as any one might see proper to offer. Such did not depreciate the reputation of the architect, or lower him in the estimation of an appreciating public, but the result was rather a commendation of his merits and a fuller confidence in his ability. Whether or not he received any hints that caused him to modify his plans in any particular I do not know, but one thing is certain, his work suffered not from the criticisms passed thereon, public though they were. Of course this could not be done in all cases; but it could be done in many, very much to the advantage of the work, perhaps, and more to the satisfaction of those financially interested. I do not mean to say that we should trespass on the rights of the eminent domain, which is the special professional territory of public officers charged with such work, nor would I for a moment commend impertinent interference with the legitimate prerogative of those who hold the reins of professional control in public works of engineering, but I do mean to say that we may carry professional courtesy too far, as doctors do, who allow the patient to die rather than that they should violate the self-constituted rules of professional etiquette. I do not think we should consider ourselves guilty of an unpardonable sin if we take professional cognizance of works of engineering of a public character. No good engineer is conceited enough to think that he is the embodiment of knowledge and wisdom, and he who is the most expert in his profession is always ready to listen to friendly suggestions. Sometimes engineers in public offices are placed in an unenviable position by political gamesters, who force them into professional pawn or checkmate their best moves by the castles and knights of political legerdemain.

Of course, such might be made subject to abuse by selfish and envious men, or active, unscrupulous competitors who, actuated by impure motives, might try to embrace the opportunity to depreciate the value of the work and detract from the reputation of the engineer; but that could be easily averted, and, if tried, the rebound on the person so trying would be much more serious than upon the person on which the attempt would be made. Every work of magnitude, which is intended to be enduring for

centuries it may be, would lose none of its importance, nor would he who plans the same, lose any of his merit by eliciting the suggestions of those who would be able to give them intelligently and well. Some improvements might be made if the planner would listen to learn.

I know, if the plans of the slowly ascending pile on Fourth and Smithfield had been submitted to public inspection, and the suggestions heeded, our Chamber of Commerce would have been spared the trouble of going to Washington to have the classical faces shaved off from the arches which they disgrace, and several other betterments might be yet enjoyed by the generations yet unborn who may be present at its completion and dedication. Public works, either Municipal, State or National, which are of sufficient importance, either from a financial or professional view, as to be worthy of the best that can be educed in their line, should receive the attention of our Society, and be subjected to the ordeal of a just, fair, candid, and professional criticism and discussion. None will be hurt, and the conscientious engineer, who wants to furnish the best at his command, will not be offended at the exercise of professional criticism delivered in a professional and courteous manner.

The honorable Governor of our Commonwealth has deemed it of sufficient importance to the people to recommend the State Legislature to consider the practicability of legislating for the improvement of our highways; then why should not our Society, in the exercise of its best judgment, make suggestions to our legislators that would aid them in legislating intelligently on the subject? Where could suggestions better come from than from a society that numbers so many engineers amongst its membership.

I would recommend the appointment of a Special Committee who would be charged with the duty of suggesting a form of procedure relative to the construction and maintenance of the public highways that would inure to the public weal. Let not our Commonwealth lag in the race of progress, and let us assist to push forward the car of improvement. The subject of a uniform legislation relative to bridges has been agitated by several of the sister societies of the country, and a committee was appointed by this

Society to co-operate with them, but nothing has been yet done towards any definite action in the matter. Our "Committee on Tests" has not been *dead*, but *sleeping*, during the year, and the Special Committee on the subject of drainage or sewerage on the South Side, and of high and low water lines along our river shores, have also taken matters very easy, and no report is forthcoming from either of them. I believe it is a fact that they have not even met. I recommend to my worthy successor that he awake them to action.

As a healthy and vigorous boy outgrows his clothes, so our Society has outgrown the limits of its room accommodation for meetings, and even for the accommodation of our increasing library. And, as this is the last year of our lease of this room, the question is where and how shall we procure suitable quarters to accommodate the Society in the future. I would suggest that, as there are quite a number of societies, such as the Photographers, the Microscopic and other societies who, I understand, have not rooms sufficiently capacious to accommodate their meetings, we confer with them in reference to procuring such rooms as would be advantageous to all. One meeting hall could accommodate all, and the cost distributed amongst all would not be oppressive on either. No society would lose its own identity, but each would retain its individuality as now, and have its own special rooms, the combination being for mutual benefit financially. Other benefits would no doubt accrue by friendly intercourse. A kind of Academy of Science, if you please, could practically thus be formed, each society being a section thereof. I would recommend a committee be appointed early in the year to confer with whomsoever may be desirous of attaining that end, and project a basis for united effort which will tend to mutual benefit.

It affords me great pleasure to testify to the uniform kindness and courtesy you have always extended to the Chair during the year, which has made the duty of presiding a matter of form. The exceptionally good order preserved during the meetings is worthy of mention, and I hope that we may make great advancement during the year, and I kindly ask the continuance of the

same hearty expression of good will and model action to the Chair during the coming year as you have always manifested towards your retiring President.

A. DEMPSTER.

The election of officers being next in order, tellers were appointed, and reported the result of the balloting, viz.: President, one year, J. A. Brashear; Vice President, two years, A. E. Hunt; Directors, two years, William Metcalf, Max J. Becker; Secretary, one year, S. M. Wickersham; Treasurer, one year, A. E. Frost.

After the announcement of the election the Society adjourned.

S. M. WICKERSHAM,
Secretary.

FEBRUARY 19TH, 1889.

THE Society met at their rooms at 8 o'clock, P.M., Max J. Becker in the chair.

Directors Roberts and Metcalf and 47 members and visitors being present.

Charles E. Billen, C.E., was admitted to membership.

The consideration of Sundry Road Laws now pending in the State Legislature was referred to a special committee consisting of Thomas P. Roberts, C.E., Chairman; Charles Davis, County Engineer, A. Dempster, C.E., T. H. Johnson, C.E. and A. Kirk.

A communication from the Kansas Club of Engineers in reference to supervision of bridges was ordered filed.

A proposal for interchange of privileges between engineering societies was read from Engineers' Club of Kansas City, and referred to a committee consisting of W. L. Scaife, Chairman, A. E. Hunt, and W. S. Davison.

Prof. John W. Langley read as follows a paper on

INTERNATIONAL STANDARD OF ANALYSIS OF IRON AND STEEL.

The advance which the last few years have brought about in the application of the sciences of chemistry and mechanics to the constructive arts of metallurgy and engineering is very great; and

nothing, perhaps, more distinctly marks off the present century from those which have preceded it than the extent to which scientific knowledge and methods are applied to increase the scope and precision of manufacturing operations, or to widen the field of invention. This is a truth long since recognized, and one which is familiar to every professional man; but the counterpart of it is also true: that these improved industrial and engineering operations of the day have reacted forcibly on the sciences, demanding of their followers greater precision of results and greatly more rapid methods of working. Two branches of science have felt this stimulus with special force; they are electricity and analytical chemistry.

The electrical engineer now makes daily, as a matter of routine, measurements which were quite impossible twenty years ago. And the analytical chemist is expected to arrive at results in eight or ten hours, which, if they could have been done at all twenty years ago, would have demanded one or two weeks of labor, and even then would have been far less accurate.

No line of manufactures have made heavier demands on the professional man than those of iron and steel, including the structural applications which spring from them. Engineers now specify the quality of the metal they wish within very narrow limits, and demand that it be submitted to extremely searching tests; occasionally they also specify a particular composition, but whether they do the latter or not, for the manufacturer it is always primarily a question of composition which he must first know and next regulate with almost mathematical precision.

For instance, in some kinds of steel the carbon must be adjusted to $\pm$ 1 part in 5000 of iron; phosphorus to $\pm$ 1 part in 10,000; and sulphur to $\pm$ 1 part in 30,000, besides keeping a close watch on silicon, manganese, and one or two other elements.

Obviously, this can only be done by chemical analysis supplemented by manufacturing skill, but the analysis must be fairly accurate or the skill will be of little avail. The present condition and future improvement of the iron industries is therefore largely a matter of applied chemistry, and for purposes of illustration, this science might be called a species of telescope which en-

ables us to look into a block of ore or a lump of metal and see what is inside of it, otherwise, we are but groping in a twilight mist of old traditional practices and rules of thumb.

But this all-important aid to vision is far from perfect, and has, moreover, a fallible human eye behind it; hence, arises much practical difficulty, discrepancies of analysis, conflict of reports ending sometimes in lawsuits. The manufacturer sends material which he thinks is good and it is rejected by the purchaser, or sometimes the steel maker may let an article go out which he knows is on the shady side of the debatable line, and yet the experts of a government board may pass it with approval. These cases are of not infrequent occurrence, but it may be confidently asserted that where fraud is absent, the cause of these troubles is, ninety times out of a hundred, due to the fact that the parties to the transaction have not before them definite and authoritative standards, chemical and mechanical, of the material in dispute. The governments of the world long ago established standards of weights and length as well as of the value of coins, without which commerce and the arts would be impossible. Now, if we will think for a moment, what would be the result in the engineering and constructive arts if there was no common understanding about the value of the foot, the yard, and the metre; or the effect upon commerce if it was impossible to learn the worth of the dollar, the franc, or the pound sterling, it is pertinent to ask why the great metal trades are to-day, industrially speaking, in the condition of barbarians who do not possess anywhere an authoritative standard of the chemical composition or the mechanical properties of a single one of their products.

I will venture to repeat that statement under a slightly changed wording—There does not to-day exist anywhere in the world, a piece of metal whose physical and chemical individuality is known in the same authoritative way in which we know the length of the standard metre bar in Paris or of the standard yard in London.

The immediate and practical need of standards of composition arises from the following considerations:

The precision of analysis is now so great that it is sensibly limited by the conditions influencing two of the most important

instruments connected with it; these are the balance and the human brain.

The final weighings in analysis often deal with quantities so small that the influence of temperature becomes of great importance. The difference of temperature between that of the room and of the interior of the balance case may easily cause an apparent loss or gain in weight of a train of absorption tubes of .001 gram. It is nearly impossible to weigh such a train to within $\pm$ .0001 gram. because of the differences of temperature between the two arms of a balance if it is in a room artificially heated. Another cause of error lies in the fact that platinum crucibles condense a film of air on their surface and their weight may thus be affected by the varying hygrometric state of the atmosphere from day to day.

The human brain is subject to still more erratic influences. Astronomers have long known that two observers can rarely record an interval of time alike. One of them may note the passage of the image of a star across a wire one-tenth of a second late, another observer two-tenths late, another observer one-tenth *too soon*, and so on. This is called personal equation, and is connected with the velocity of nervous propagation and the rapidity of intellectual action. Now, chemists, too, have their personal equation; only with them it is not a matter of time-rate, but instead, takes the form of differences in the appreciation of color, or of temperature, or of odor; so that two men, working side by side and by the same method, may always obtain results which tend to differ from each other by a constant amount, this departure being due to physiological and psychical causes; in short, a chemist's personal equation.

A still more important source of variation is caused by different methods of analysis which introduce into chemistry a class of errors similar to those brought about in mechanics by the use of foot-rules, which depart from each other slightly in length. And as there is always a choice of methods, and, moreover, these processes are themselves constantly being modified with a view to their improvement, we have here a fertile source of discrepancies.

Now, considering these three classes of errors, viz., those of weighing, those which are personal to the operator, and those due to the process employed, it is remarkable that the differences of analytical reports are not greater than they are.

A practical remedy for most of these evils can be found in a system of international standards of iron or steel, whose composition shall be most rigidly and authoritatively determined by committees of chemists and metallurgists, appointed in the most important iron-producing countries. These committees propose to analyze a set of samples which shall be prepared in one place and distributed to the several countries; after the committees have made their reports, the standards thus established will probably be deposited in some public place, and small portions of them can then be issued to properly-qualified applicants. A chemist obtaining a sample of the standards can then check his own work by them, and thus he can determine a factor by which in future his results must be multiplied to make them agree with the standards. It is confidently believed that this plan, if successfully carried out, will result in a very considerable degree of uniformity in the analysis of these important metals in different countries, and will greatly lessen those scientific and commercial disputes which now sometimes assume formidable proportions.

It was my fortune this summer to submit the above ideas to some of the principal chemists and metallurgists of Europe, and to find they approved of them and were willing to give them the authority of their support. The result of personal interviews and considerable correspondence is that committees have been formed in four European countries and the United States.

These committees are as follows:

In Sweden, Professor Richard Åkerman, of the Royal School of Mines.

In Germany, the Minister of Public Works has officially assumed charge of the investigation at national expense.

In England, the British Association for the Advancement of Science has appointed a committee consisting of Professor Roberts Austen, Sir F. Abel, Professor J. W. Langley, Mr. John Spiller, Mr. Edward Riley, Mr. G. J. Snelus, Professor Tilden, and Mr.

Thomas Turner. This committee has already issued a printed circular.

In France, Monsieur Ferd. Gautier will have charge of the work.

In the United States the subject has been submitted to the American Society of Civil Engineers and to the governing board of the University of Michigan, who have appointed a joint committee consisting of Messrs. William Metcalf, Thomas Rodd, and Alfred E. Hunt, of the Society of Civil Engineers, with Professors J. W. Dangley, A. B. Prescott, and M. E. Cooley, of the University of Michigan.

The plan, as agreed on thus far by the committees of the several countries, proposes that from 150 to 300 kilos of steel, representing as nearly as possible 1.3, 0.8, 0.4, and 0.15 per cent. of total carbon respectively be prepared in five lots. After the ingots are cast, the outer skin is to be removed and then the metal cut into fine shavings, which shall then be crushed, sieved, and intimately mixed. These shavings shall then be hermetically sealed, and an equal portion of each sample sent to each of the five countries above named, where they will be independently analyzed. When the reports are completed they will be interchanged, and the average of all will then be deemed the true and authoritative composition of the international standard.

To the writer of this paper has been assigned the duty of preparing these samples, a task which would have been quite impossible except for the great interest which Messrs. Miller, Metcalf, and Parkin have shown in furthering the cause of metallurgy, and the practical side of chemical analysis. To their co-operation is due the fact that the preparation of the samples is now well under way at the Crescent Steel Works.

In conclusion, the writer begs to say, that the establishment of a set of international standards is a matter which appeals not to chemists only, but to every engineer and iron and steel worker in the land; he therefore ventures to hope for the co-operation of this Society in the work by their advice and suggestions as to the best methods of dividing the metal to secure absolute uniformity, and also that some of the chemists of its membership may be willing to take, as a labor of love for science, some part of the very large amount of analytical work called for.

Discussion of Paper.

J. W. Langley: And I may add as a supplement to the paper a few portions of the circular which the English Committee have issued, copies of which were received in this country a short time ago. After giving a list of the Committee it goes on:

It is proposed that the Committee shall co-operate with other similar Committees in the careful testing of specimens of iron and steel, the chemical composition of which shall have been carefully determined. The specimens adopted as standard shall be so considered and the same recognized as authority and shall be used thereafter.

H. D. Hibbard: I would like to ask the size of the ingots in which this sample is cast?

J. W. Langley: The ingots which have already been prepared are 3½ or 4 inches square and about 36 inches in length. They are then mounted in a lathe and turned up.

H. D. Hibbard: Is the metal thus prepared to insure all the ingots to be the same in uniformity as if mixed in a ladle?

J. W. Langley: No; that is not necessary. One ingot of each of the standard carbons shall be prepared; the weight being 90 pounds per ingot.

H. D. Hibbard: I thought the ingot would possibly be larger, but the small ingot does away with the objection I thought of; that is, the segregation always found in the large ingot. I have found difficulty in this respect, in preparing standards for color-carbon determinations. After selecting a piece suitable otherwise, I found it necessary to take drillings from numerous different places in the bar for comparison with each other to ensure reasonable uniformity in the standard. That was always in steel cast in ingots larger than 4 inches square.

W. Metcalf: In regard to that matter of uniformity, there is little want of it in the small ingot. There may be some segregation, but I noticed from the paper that it is proposed after the ingots are cut into the very fine shavings they are pulverized, then sifted and mixed, and incorporated through one another so

that the final result of this extremely fine powder of steel must be practically uniform.

H. D. Hibbard: How fine is that?

W. Metcalf: He speaks of 1–16 mesh, but a good deal will be finer than that. It is thoroughly mixed up, and this removes the objections to the segregation in the larger ingot.

F. C. Phillips: As to the benefit of this measure, it seems to me that no criticism is necessary. It is a most admirable move, and it is strange that something of the kind has never been attempted before.

It seems to me, however, there is one difficulty in this matter. I understand Prof. Langley to say that the quantity is very limited; that the steel works' owner will be fortunate if he succeeds in getting an allotment of 10 grammes. Now, as the bar is standard, and as it is probable that a number of determinations will be needed for each cast of metal, it would seem rather unfortunate that larger quantities cannot be provided. Of course, the difficulty of getting homogeneous metals will stand largely in the way of that, but it is to be wished that the Committee who have this matter in charge can arrange in some way so as to allow of comparisons being made in larger quantities. I do not know whether that can be done. As to the plan the measure proposed might be extended to a great many other things besides iron and steel with great advantage. I hope to see it carried through, and that our Society ought to give its full endorsement, as I have no doubt it will.

W. E. Koch: I do not think there is much difficulty in keeping a standard if you once find it. In the early days of steel making we had a standard. Unfortunately, we only started in with a small bar, and we ran out of the standard, but soon recovered it by making comparisons with other bars, and we kept the same standard, although the bars were used up two or three times.

But I think the Committee will do us a good turn if they will define what steel is. I had some stuff sent me the other day called steel, and when I came to analyze it I found it had about 3–10 silicon, 1–10 phosphorus, 9–10 manganese, .35 carbon, besides traces of other ingredients.

H. D. Hibbard: It has been my experience that it is better to have the pieces sifted as near one size as possible; that is, in the sifting the pieces should be no larger than a certain size, and no smaller, because it will be found that the finer parts will be a little different in their composition from the coarser parts, so if in these analyses the mixture is made half fine and half coarse, there would be a little difference in their results.

F. C. Phillips: I agree with the last speaker on that point. I think it would be necessary that the parts be of the same size.

T. P. Roberts: I am not very much of a chemist but I think I can appreciate the point made by these gentlemen, and it will suggest this idea. We see in breaking coal that the finer parts retain much the greater proportion of sulphur. In coal mines, in taking out the coal, the finer parts seem to give off the refuse, and this is natural, because I think it is on the line of the sulphur that the coal will break. It occurs to me, therefore, that specimens of such comminuted metals may vary very greatly and be to each other in proportion to their relative fineness.

J. W. Langley: I will take a moment to reply to one or two of the suggestions made. One in regard to the necessity of taking the difference between two screenings. This will be watched.

It is very unfortunate that large quantities of the steel cannot very well be prepared, but only a practical steel maker can have any idea of the large quantities of material which have to be dealt with to get the 90 parts thoroughly homogeneous. Indeed, the four ingots already prepared represent not less than 5 to 10 tons of steel, and if we attempt to get a double set of these four ingots, it would represent more like 1000 tons of steel, as the difficulty would increase something like a square of the number; therefore, the quantity of standard authority must be somewhat small.

Probably the remedy would be to make the allotment of samples limited to those who are specially interested in such manufactures, and a few given to the chemists who can multiply copies in the same way as our weights and measures that are to be found in every grocery store. Only one copy of the standard of weight

is in this country—that in Washington—and in the course of time it may be possible to perpetuate them on a large scale.

T. P. ROBERTS: I would like to ask in regard to these borings: do you use oil or water?

J. W. LANGLEY; No; they are perfectly dry.

A MEMBER: There must be a considerable heat developed.

J. W. LANGLEY: Yes; a great heat.

T. P. ROBERTS: Do you think any part of the tools may grind off and get into the borings?

J. W. LANGLEY: There must be; but only a very minute quantity.

T. M. HOPKE: Will the various chemists who make these analyses be expected in their reports to give the method used?

J. W. LANGLEY: Certainly.

H. D. Hibbard read the following paper exhibiting, also, many specimens of various metals welded by the process described.

THOMSON ELECTRIC WELDING PROCESS.*

This has attracted considerable notice in scientific papers for the past year because of its scientific value, but now it is assuming its proper position of usefulness in the world. To this end a company has been formed which controls and is introducing it, named the Thomson Electric Welding Co.

It is the especial pride of the inventor, Prof. Elihu Thomson, and I was told that he claims more originality in this line than in the other applications of electricity with which he has had such great success.

Results are obtained hitherto deemed impossible. Brass, copper, lead, tin, zinc, German silver, bronze, silver, gold, platinum, steel, wrought-iron and cast-iron are welded together and in various combination, one with another.

For a list of the actual and proposed uses I refer you to their pamphlet.

The fundamental principle involved is not new. It is that resistance to an electric current transforms a part of the energy into heat, but the application to this purpose is novel and promises to find a large field for work.

The principle is applied by causing the ends of the pieces to be welded to form the poles of an electric current of proper strength. The pieces are held in suitable heavy copper clamps, one of which is insulated from the frame of the machine by thin mica plates, the bolts which hold it being insulated by means of mica ferrules and washers. The current used is of very low potential, from 1 to 2 volts, so that insulation is easily effected. The quantity of electricity is very great, running into thousands of amperes, this varying, of course, with the size of the pieces worked upon about as the area of the section. There is no danger to life in using such a current as it will not pass through the human body.

One of the jaws or clamps which hold the work can be moved towards the other by turning a screw so that the pieces may be forced together when properly heated.

The writer and a friend recently visited the office and works of the Company, saw the process in operation and obtained a few specimens, which are here shown. At the office in Boston are many samples of the work done, including most of the metals named above. The largest piece shown which had been welded was a 2-inch round iron bar. After inspection of these, the train was taken for Lynn, where the works of the Company are situated.

The shop itself, equipped for the manufacture of the machines, does not require description. They have machines, however, ready to illustrate the process, and two welds were made in our presence, one of which, the larger, I was kindly permitted to take away. It was this 1¼-inch round iron bar, which has since been split through the weld, and one-half etched with acid developing its structure. The weld is apparently perfect. The pieces had been dressed, that is, slightly rounded on the ends and placed in the machine before we reached the works. The actual time the current was passing was, I estimated without actually timing, from twenty to thirty seconds, the heat gradually rising to a beautiful welding heat, the pieces being forced together at the time, producing the upsetting you observe. Two pinches of flux, dehydrated borax, I think, were used on this weld. The work required about 30-horse-power.

The other weld we saw made was of half-inch rounds of soft

steel. A few seconds only were required to make the weld after the pieces were in the machine.

I have said that the ends to be welded formed the poles of the circuit. This is not strictly true, as the pieces are touching when the current is started, but the contact is so imperfect that the great resistance is at that point.

The heat was sufficient to have admitted dressing down the weld on an anvil if quickly done but the heat is so localized at the weld that the temperature falls quickly because of the conduction of heat to the cold adjacent parts of the bar.

In one of his patents Prof. Thomson describes an arrangement for hammering the weld while in the machine, and the heat is kept up by the electric current. Though the welded part is as large or larger than the rest of the bar, its high temperature makes it the point of greatest resistance, and therefore of greatest conversion of electric energy into heat. So the temperature is maintained as long as the current passes. Welds may also be dressed cold with machine tools with satisfactory results.

The absence of foreign matter such as might get into the joint from a coal fire makes these welds peculiarly reliable. Numerous tests pulled in a machine show the welds of the same metal to be practically of the same strength as the rest of the bar. Welds of unlike metals are, however, likely to give way at the weld.

The Company does not propose to do welding itself commercially, but to furnish machines to its customers on suitable terms. The only machines sent out so far have been to wire works. Copper wire welded as the samples you see here, are drawn down through successive passes, the welds being indistinguishable from the rest of the wire. The weld is an ideal one.

Chains made with two welds in each link somewhat upset are stronger at the weld than elsewhere, and the upsetting serves to prevent them kinking.

Rings closed with a single weld are also made by this process. The current largely seeks the short circuit through the joint in preference to going around the ring, heating it and enabling the joint to be made.

Welding pipes of iron, steel, brass, and lead is another very

useful application of this process. Lead and brass which are joined by fusing the abutting ends join very smoothly. Iron and steel merely becoming soft are upset in the machine and flared out so that there is an enlargement of the bore just at the weld.

A machine was in the shop just completed for brazing bicycle yokes. Of course, the degree of heat needed is far below that of welding, but it is under good control and the proper amount can be applied.

For each different purpose a special machine must be contrived to give the proper shaped clamps and other proportions suited to the work.

This small bar formed of sections of iron, German silver, brass and copper, welded together in that order illustrates some of the possibilities of the process.

In view of the limitations which have been put on the meaning of the term "weld" by members of this Society, perhaps some other word should be invented to describe the results obtained by this process. The joining includes all steps from sticking together when pasty to actual fusion of the parts united.

Discussion of Mr. Hibbard's Paper on Welding by Electricity.

Prof. Langley: I might add one bit of testimony to the facts stated in the paper. I had the pleasure last summer of seeing aluminium welded by this process—2 ½-inch rods perfectly welded together in about 30 seconds.

W. E. Koch: In 1881, I think it was, the late Sir W. Siemens had a 20 horse-power engine and dynamos, and made some electrical welding experiments. We found with such welds that when we pulled them it was all right. We would take a bar, for instance, weld it in that manner, and if it was pulled the weld was all right, but if we gave it a smart knock over an anvil with a hammer it would drop off just below the weld, and I would like to know if these parties Mr. Hibbard speaks of have had the same trouble. The break showed a crystalline fracture.

H. D. Hibbard: I do not know whether they had any such trouble or not.

W. E. KOCH: The process was abandoned probably on account of this trouble. I have never been able to find anything about it, but it may be by using a low carbon steel it might give a different result.

WM. METCALF: Did you ever try heating these bars and forging down to the size of the weld?

W. E. KOCH: That was all right when we took and forged them. They came all right.

T. P. ROBERTS: I think, Mr. President, the trouble Mr. Koch complains of must originate with the rapid absorption of heat, for in the paper it spoke of the bar being quickly brought up to the welding-point, and that it cooled rapidly. I suggest the idea that there was a diffusion of heat in some way; the movement of the particles on the line where that fracture was, developed the crystalline structure. If that bar had been heated immediately afterward and left to cool gradually it might have relieved that difficulty.

H. D. HIBBARD: It looks to me from Mr. Koch's admission that it was solely a question of heat without work, which we know is injurious. The steel or iron there heated was over-heated, without any work being done. Of course, a blacksmith who hammers every part of the bar forging down to the weld removes the difficulty.

WM. METCALF: I think it was altogether heat without work. Changes in the temperature will affect the grain both in steel and in iron. If you take two bars of steel and stick them together, and bring them up to a welding-heat in a very small length of the bar, it is absolutely certain that there will be a difference in the steel for that portion, from that portion away from the weld, or in other parts of the bar. The fact that the steel has been brought to a very high heat, and that it has cooled very rapidly, shows that this change in the grain must have been in the neighborhood of the weld, and that sudden change in temperature would certainly make any piece of steel brittle, more or less, according to the quantity of carbon. And it would naturally break off at the point Mr. Koch said it did break.

It was for that reason I asked if he had tried a specimen weld

by afterwards hammering it down, for the putting on of so much mechanical work at a lower heat, would bring the grain back to the condition it was in in the original bar, and I think that Mr. Koch's experience will be repeated by everybody who makes an electrical weld of that kind, unless he uses some means to remove the difference in the grain, and the strain in the steel produced by it. That is about the simple explanation of it.

G. LINDENTHAL: I would like to ask if Mr. Hibbard thinks that if hard wire, after being welded together and worked in the way Mr. Metcalf suggested, that the weld will be as strong as the wire, or only give the strength of the original steel.

H. D. HIBBARD: I think the strength of the weld would be no more than that of the wire heated by any other means. The increase in strength due to drawing would be removed by the heating.

G. LINDENTHAL: Would it have the same strength as the rest of the wire?

W. METCALF: I will say, in answer to Mr. Lindenthal, that if I had to build a wire bridge I certainly would not weld the wire.

G. LINDENTHAL: Ever since I have known anything about the subject of eye-bars, which were made years ago by welding on the heads, I never questioned that the weld can be made good, but I question very much whether every weld is good. And in the matter of wire, I would certainly be very loath to weld it together, and consider it as good in the weld as in any other part.

H. D. HIBBARD: For this class of work probably another system of electric welding in which the piece of work forms one pole of the circuit, the other being a carbon-point would be better suited. By this, local heating and welding of any portion of the work may be accomplished.

The Society adjourned at 9.45 o'clock, P.M.

S. M. WICKERSHAM,
Secretary.

MARCH 19TH, 1889.

SOCIETY met at their rooms at 8 o'clock P.M.

President J. A. Brashear in the chair.

Vice-Presidents, W. L. Scaife and A. E. Hunt.

Directors, T. P. Roberts and Chas. Davis; and thirty-five members and visitors being present.

Messrs. Lewis S. Clarke, Robert A. McKean and A. C. Kerr were duly elected to membership. W. L. Scaife, made the following report from the Committee on Interchange of Privileges:

Gentlemen: Your Committee appointed to consider the plan of arranging the transfer of members from one local society to another, suggested by the Engineers' Club of Kansas City, beg leave to submit the following report:

Whether we consider the matter as one of individual interest and profit, or of public policy, the proposal to open the doors of the different societies throughout the country to the members of any one of them, cannot fail to meet with general approval. There is room, however, for difference of opinion as to the best means of accomplishing this object.

Your Committee would suggest the following method as one of several that might be adopted.

Suppose that the Engineers' Societies of Kansas City, St. Louis and Pittsburg, had agreed upon the proposed plan, and that one of our members, Mr. A. B., desired to settle in Kansas City for a time, and to join the Engineers' Club of that place. Mr. A. B., would make application for a card to our Secretary, paying the latter one dollar to cover expenses and prevent useless applications. The Secretary would give Mr. A. B. a card, stating that he was a member of this Society, and that he had paid all dues to the end of the year. On presentation of this card to the Secretary of the Kansas City Club, the latter would place his name among the list of members, with all the privileges of the Club except voting and printed *Transactions*. At the end of the year, if Mr. A. B. still remained in Kansas City, he could be admitted to full membership in that Club, with privilege of voting and *Transactions*, on compliance with their rules governing the election of members.

Should Mr. A. B., decide to move from Kansas City to St. Louis, he would receive from the Secretary of the former Club, a card stating that Mr. A. B. was a member of the Pittsburg Society, transferred to Kansas City, or a member of the latter Club alone, if he had been formally elected, and that his dues were paid to the end of the year.

On presentation of this card to the Secretary of the St. Louis Society, Mr. A. B. would be received just as he had been in Kansas City. He would, of course, be subject to all the rules of each Society, while connected with it, except the payment of dues and assessments, to the end of the year in which his card was issued.

He should receive printed *Transactions* only from the societies to which he had paid all dues covering the period during which he desired to obtain them. Respectfully submitted,

W. L. SCAIFE,
GEO. S. DAVISON,
ALFRED E. HUNT.

On motion, it was ordered that a copy be sent to the Kansas City Club, with the assurance that this Society is ready to name a committee to act with a joint committee for arranging a scheme for final action among the various engineering societies.

Thos. H. Johnson, from the Committee on Roads, read the following report:

Your Committee begs leave to report, that, during the month since we were appointed by the Society, to examine and report upon proposed laws, to be acted upon by the Legislature of Pennsylvania, affecting the highways of the various counties, we have had a number of meetings, and although the time has been short for the collection of papers and documents bearing upon the subject, we have deemed it best to present for consideration of the Society, a draft of a bill, which, if favorably acted upon, we recommend be immediately forwarded to Harrisburg.

Numerous bills have already been formulated by members of the Legislature and are now in the hands of the appropriate committees; but if our Society is permitted to hope that any of its

suggestions are to form a part of the State laws, it is important that immediate action be taken, for it is thought the Legislature may adjourn about April 25th.

The draft of the bill submitted by your Committee speaks for itself, and if it can be improved upon, by suggestions made in this meeting of the general Society, the Committee will be glad to have its errors or omissions pointed out.

The subject committed to us is one of great and peculiar interest, not only to the State of Pennsylvania, but we may say of national interest. It is of interest, not only to civil engineers, but to all classes of citizens. Engineers, however, are perhaps, in some respects, better qualified by reason of their large personal knowledge of the topography of the State, and its means of communication, to discuss the practical benefits of, and the urgent necessity for, improved roadways in the country districts, than are other classes, whose duties do not require them to travel afoot frequently, and to great distances from their homes. That there is a peculiar propriety, therefore, in engineers discussing the road problem, there can be no doubt. Of one thing we are sure, viz.: that if engineers had been called upon to lay out, construct and supervise the maintenance of the roads in the Eastern States, during the last forty years, a vastly different picture would be found from what appears to-day.

Most of the counties of Pennsylvania have come to a complete standstill, so far as increase in population and value of natural products are concerned. The tide of immigration from Europe passes unceasingly through her territory without stopping; although the proportion of unbroken or forest land in Pennsylvania to cultivated land is still very large. By the census of 1880, it is shown that in Pennsylvania the percentage of forest to total area was 24.3. Of the remaining 76 per cent. nearly one-half is non-cultivated or waste land. In New York, the per cent. of forest to total area was 26.2; in Maryland 31.7, and in New Jersey as much as 48.8. It is therefore a fact, that these States, which embrace the chief commercial and manufacturing cities of the Union, and the densest population, considering their combined

area, have a greater proportion of unbroken ground, than other regions of the same size in the more sparsely populated regions of the West. Here, then, there is room for many thousands of settlers. The farming lands of these States are only valuable on the narrow strips bounded by a few miles width, through which the railroads pass.

The hue and cry has gone forth that Pennsylvania farmers cannot compete with the wheat raisers of Minnesota and Dakota, because of some mysterious evil that the railroads have done them. There are, no doubt, causes of complaint by the eastern farmers of the railway administration, but sifted down, most of the troubles which afflict the Pennsylvania agriculturists originate in their inefficient means of reaching the markets.

To the farmer, the market simply means the nearest railway station. If he be located ten miles distant from the railway, the character of the roads often requires a whole day's labor with a team of horses to transport 600 or 700 lbs. of produce to the station. It never occurs to those who lay out and construct these roads, what a loss this extravagant use of horse-power involves. Land at the railroad may be worth $100 per acre; while the same kind of soil ten miles distant may not be worth more than one-third of such an amount. If he could traverse the ten miles in less time and with three times the load, the farmer could market his produce with one-third the number of trips; and the time and expenditure of power lost on the road, would go to the betterment of his farm. He would live better, have more comforts, and be able to have better schools for the education of his children.

Good roads mean another thing to the farmer, an improved breed of horses. If the farmers' sons have good horses, and good roads to exercise them on, they will form an attachment for the country, which no allurement of the city can detract from. As it is, however, the farmers' sons grow restless with the plodding ways of their fathers, and seek opportunity to emigrate. It is no wonder, for what is the use of schools and education, except to advance ideas of comfort and happiness; and there can certainly be no general happiness in a district where the roads are so bad

that for months at a time people can see nothing of their neighbors?

The salient points of the law which your Committee would like to see enacted, should provide for three things being done, in connection with the roads.

1st. As to their location. It is too often the case that great detours are made by the township roads to avoid cutting the farm of some influential citizen in two. It is regarded as a terrible affliction by them to have to open two gates to reach a field with a mowing machine, where one would do. The property, it is also claimed, will not divide up so well when the farmer is dead. For these and similar reasons all the other farmers and the travelling public must forever pay a tax in the form of lost time and wasted horse-power for every load hauled around his premises. There are many thousands of these "toll gates" on the 90,000 miles of roads in this State. The very farmer who maintains one such taxing station on his property and thinks he has gained a point, loses, in going to market, more than he has gained, by paying similar tolls to others equally favored?

Our roads are susceptible of great improvement in their location. Instead of 90,000 miles, there might be several thousand miles less. That is to say, the kinks and bends which could be removed from them would reduce their length by some such figure, with corresponding reduction in the annual cost of maintenance and in the number of miles annually travelled by vehicles of all kinds.

But besides the horizontal kinks and bends here referred to, there are hills or vertical bends to be eliminated in the proper location of the roads. Farmers do not appear to regard steep grades on their roads as a very serious evil. If they could see inside of their horses' stomachs, or feel the animal's heart beat on an up grade, something in the manner of the locomotive engineer looking into the firebox of his engine, he would learn that the two machines are identically alike in consuming more material on an up grade than on a level. A pound of coal has a known and fixed value in evaporating water in the creation of steam. "Low grades" means a saving of steam and hence economy in the use of coal.

So, also, in the animal "engine" a pound of oats or a pound of hay is capable of developing a certain number of heat units, which may be displayed in energy, *i.e.*, power. In fact a horse is a far more perfect machine than any engine which can possibly be constructed, but while more perfect is much more liable to injury when overtaxed. If time permitted, it would be an easy task to prove that the State could afford to spend millions of dollars annually in improving its roads to save this unnecessary waste of horse-power, to say nothing of the positive benefit to the health, strength, and breed, which would accrue to the animals themselves by the construction of such roads.

The second point to which legislative attention is requested, is the construction of the roads. It should be the aim of the law to encourage the construction of well-drained, macadamized, or gravelled roads. On this point it is scarcely worth while to discuss the engineering points involved. They are, for the main part, simple enough, though no one plan may be applicable to all portions of the State. When we speak of macadamizing the roads we do not urge the construction of too many at one time. Certain main roads, however, we believe should be designated for improvement first; and the worst parts of these to be undertaken first. This leads to the consideration of the

Classification of Roads.

Your Committee believes there are prominent roads in every county, connecting important towns, which should be first radically improved. Now it often happens that such a main highway may traverse a very poor township, or be for miles near one end of a township to which it confers but little benefit. Hence the propriety of taxing the larger community, the boroughs, and in fact the county, for certain classes of its roads. The boroughs and cities are just as much interested in having good roads leading from them, as are the farmers who use them. This we believe is a self-evident truth; nevertheless, it is not the law in this State to permit the cities and boroughs to help pay for good roads.

There can be no doubt that if the roads from the country were always passable, the supply of butter and eggs, to meet the demands of our cities and towns would come altogether from the districts adjoining the local markets. Hay is often worth five and six dollars a ton more in the Pittsburg market than it is on farms within eight and ten miles distance; owing altogether to the fact of the bad roads, which are thus responsible for entailing a double loss—a loss to the city purchaser and a loss to the producer. To the bad roads of the country we must attribute the famines and gluts in certain commodities.

We are therefore confronted with the question, shall our main country highways be improved with funds obtained from a county tax, and built under county supervision, or shall they remain, as heretofore, under laws affecting townships only?

A second class of roads more especially useful to the citizens of a local rural district, which might be termed township-roads, may continue to be constructed and maintained under township control, so far, at least, as to the amount of money to be expended upon them. We have faith in the notion that when the advantage which will accrue to the people by improved county roads is seen and appreciated, the cross-roads will likewise be improved in a good substantial manner.

The third point which we think should be cared for in the contemplated legislation, concerns the maintenance of the roads after completion. We think it can be easily shown that for the average amount of travel which the proposed macadamized roads will be called upon to bear, that the cost of their maintenance will be less of a tax upon the community than is now borne annually in so-called "road-repairs." It, however, would be taking but a narrow view of the case to assume that this is the chief advantage of having good roads, viz., to keep down taxes for renewal and repairs. Indeed, it is not promised that good roads will lower taxes in general. Increase of taxation in some shape seems inevitably to keep pace with every march towards improvement. But, very fortunately, with the march of improvement come new sources of revenue, which more than compensates for the increase

of taxation. At all events, it is certain we cannot have good roads without paying for them. This leads us to consider

The Economic Value of Good Roads.

There was a time when all the commerce and travel of this State was carried by horse-power over the public highways. The volume of traffic thus carried was such as to make toll turnpikes remunerative and attract private capital to such investments. But when the Conestoga wagon and the Concord coach became things of the past the conditions changed. No new turnpikes were built and the old ones were allowed to fall into decay, many being abandoned by their owners and turned over to the township authorities to be maintained in the same slip-shod way as other public highways. Since that time the growth of the commonwealth has been rapid and continuous, until now the annual products of the State, which must be hauled over the public roads, has reached a volume much greater than that which made toll-roads profitable in former times, though the distances to be traversed are much less. Then the tonnage was small, but the hauls were long; now the tonnage is large, but the hauls are short.

The difference in cost of hauling that tonnage over good roads and over bad or indifferent roads is an actual expense which the community encounters continuously without fully appreciating its magnitude, but which is a legitimate subject of inquiry. From Morin's experiments, made many years ago, and which are still recognized as the highest authority on the subject, the following table has been prepared, showing the average loads which each horse can draw over different kinds of road-surface, and on grades rising 10 feet per 100, 5 feet per 100 and on the level:

Kind of Road.	Grade.		
	10 Per Cent.	5 Per Cent.	Level.
	lbs.	lbs.	lbs.
Street pavement, dry and clean	1,090	1,920	8,300
Street pavement, muddy	1,040	1,800	6,250
MACADAMIZED ROAD.			
Best condition, dry, clean and smooth	1,060	1,840	6,700
Good condition, moist or with a little dust	1,000	1,660	4,700
Bad condition, ruts and muddy	890	1,390	3.000
Very bad condition, deep ruts and stiff mud	740	1,040	1,840
CLAY ROAD.			
Best condition	930	1,500	3,600
Average condition	660	900	1,400
Newly worked, not muddy	600	780	1,100

The legal grade of 5° = 8.85 per 100, and load of one horse on that grade would be, respectively, 1150, 1090 and 700 pounds for pavement, macadam and clay roads, each in good average condition.

From this it will be observed that as the steepness of the grade increases, the efficiency both of the horse and of the road-surface diminishes; that is to say, the more the horse's energy is expended in overcoming gravity, the less remains to overcome surface-resistance. For *average* conditions of each class of road, the loads hauled are in the following proportions, taking that of the clay road as 1:

	Macadam.	Pavement.
On level, ...	2.75	4.46
On 5 per cent. grade, . .	1.70	2.00
On 10 per cent. grade, . .	1.43	1.58
On legal grade 5°, . . .	1.56	1.64

The last census report gives the total quantities of the agricultural products of the State in 1879. Converting those quantites into equivalent weights (omitting orchard and garden products, which are given only in value and not in quantity), it appears that the total farm products amounted to 6,500,000 tons. Of this amount about one-half is consumed upon the farm, and the other half, or 3,250,000 tons, must be hauled by wagon for dis-

tances varying from one-half to ten, twelve or more miles. The average haul is probably not less than five miles.

We will assume that the haul is five miles, and that two loads per day are made by a two-horse team at a cost of $2.50 per day. The cost of moving the total market crops will be as follows, both in average condition and with legal grades:

	Clay Road.	Macadam.
Load for two horses, . .	1400 lbs.	2180 lbs.
No. loads for 3,250,000 tons,	4,643,000	2,981,000
Cost $1.25 per load, . .	$5,703,750	$3,726,250
Difference, . . .	$1,977,500	

This is the excess cost annually entailed upon the farm products by clay roads, as compared with turnpikes. It is enough to keep 30,000 miles of turnpike in repair, at an annual expenditure of $66 per mile.

Looked at in another way, the figures given above represent 2,321,500 days' work for a man and two horses on clay roads, as against 1,490,000 days on improved roads, a loss of 831,000 days' labor, which might have been devoted to other useful purposes.

Besides the farm products, there is quite a large tonnage of other materials, such as merchandise, machinery, coal, manufactured articles of all kinds, including farming implements, etc., which must be carried to towns not reached by railroad, or to the homes of the people in the country districts. We have at hand no data from which to estimate the amount of this tonnage, but it must be large, and will swell the aggregate loss to the general community to nearly double the sum already estimated, or, say, $4,000,000.

Mr. Andrew Carnegie, in speaking of his recent coaching trip in England, describes the roads of that country as being everywhere improved in the most complete manner, and forming a network which covers the whole country, and whose ramifications extend into the minor as well as important districts, and that these roads are maintained in a condition of the highest excellence, even exceeding those of Central Park in New York.

This description of the roads of England is confirmed by accounts from other sources. Mr. W. H. Wheeler, M. Inst. C. E., writing in the *Sanitary Engineer*, for 1887 (page 97), estimates that the saving to the people of England, by reason of the excellence of their roads, amounts to $100,000,000 yearly, in cost of transportation alone. This estimate is based not on a comparison between turnpike and clay roads, but between well-kept and neglected turnpikes, three horses on the former being rated equal to four horses on the latter. The rate which we find from the foregoing table for comparison of turnpikes with clay roads would make two horses on a turnpike equal to three on a clay road. At this rate, Mr. Wheeler's figures would become $150,000,000, an amount beside which our own estimate for the State of Pennsylvania sinks into insignificance.

In 1835 France had 45,000 miles of roads in bad condition. An eminent French engineer of that time, writing in advocacy of better methods than were then in vogue, estimated that hauling the commerce of the country over these roads cost $90,000,000, of which one-third, or $30,000,000, would be saved by putting the roads in good order. Since then, these roads have been put and maintained in a condition of the highest excellence.

The following data in relation to French roads is taken from the *Engineering News* of the current year. The roads are divided into National, Departmental, Military and Country cross-roads. The National roads are maintained entirely at the expense of the public treasury. The departments provide for the second class of roads and also partly for the military roads; and the local cross-roads are maintained by the communes, or, when of higher importance, by the departments.

In 1873, there were 223 national roads, aggregating 23,180 miles in length, of which 1632 miles were paved like a street. These roads average in width 52 feet 6 inches, or 16 m., of which 19.68 feet are for the causeway, 19.68 feet for the sideways and 13.12 feet for the ditches and embankments. The department roads are not quite so wide, the average width being 38 feet. In 1872, the aggregate length of the latter was 29,167 miles. The 28 military roads are about 932 miles long in all, and are chiefly

in the west of France, laid out after the last insurrection of Vendee. The sum of about $6,800,000 is yearly expended in making new roads or repairing old ones. The cross-roads are managed by a special bureau under the Minister of the Interior, which employs 3000 inspectors and 42,000 workmen specially charged with the duty of keeping these roads in repair. In 1872, these cross-roads aggregated 338,273 miles in length.

The Government grants yearly $1,150,000 towards the extension and repair of these roads; the balance of funds required is furnished by the communes. The commune is the administrative unit of France. France has an area of 204,091 square miles, or is 4.436 times larger than Pennsylvania.

It would be difficult to estimate how large a factor these roads have been in building up that financial prosperity which enabled France to pay "ten milliards" to Germany without bankruptcy.

But the diminished cost of hauling is not the only return which a community derives from good roads. At certain seasons of the year the clay soil of this State becomes impracticable for loaded vehicles. As a result of this, the crops must be marketed when the roads will permit, and this in turn produces a glutted market with prices at the lowest ebb. Perhaps a few days or weeks later, a change in the weather breaks up the roads, and the honest farmer is compelled to sit at home with folded hands, while the prices of his products go steadily higher and higher.

With good roads this is all changed. The market is always accessible, and prices are not sent away down because everyone can get there, nor away up because no one can. One active cause of fluctuation is eliminated, and the range of fluctuation is reduced to narrower limits. With bad roads the great bulk of farm products are sold at the *lowest* prices; with good roads, at *average* prices, while to each individual is opened the possibility, by the exercise of sound discretion, of reaching the market when at its highest.

The amount of good hard cash which the farmers of Pennsylvania lose every year in this way is difficult to estimate, but it must be enormous. Take the single item of a hay crop, which in the census year amounted to 2,811,517 tons. Of this the greater part (say two-thirds) was consumed by the farm stock, and the

remainder (940,000 tons) was hauled to market. For purpose of illustration we will assume that the price of hay has ranged between $10 and $15, and that owing to the condition of the roads 800,000 tons had been sold at the lesser price, and 140,000 tons only obtained the higher price. The total sum then realized by the producers would be $10,000,000, or an average all around of $10.74 per ton. But with good roads the supply would have been more evenly regulated to the demand; the lowest price would not have been so low nor the highest price so high, and there would have been less difference in the quantities sold at the extreme prices. To carry out this illustration, suppose that 500,000 tons had been sold at $11 and 440,000 tons at $14. The total result would then be $11,660,000, or $12.36 per ton. The gain to the producers being in that case $1,560,000, or quite a snug sum lost on a single item of farm product.

While these figures are not based on actual data, they are not beyond the range of possibility, and serve to show that the actual cash loss sustained by the farmers of the State, through bad roads, probably amounts to several millions of dollars every year. To estimate this at $6,000,000 would certainly be much too low, and yet $6,000,000 is 6 per cent. interest on $100,000,000 of invested capital.

Returns for investments of this kind are had also through another channel. It is found as a direct result of the construction of good roads, that property is enhanced in value. Farming lands situated on or near the line of a good turnpike always find the most ready sale, at prices ranging from 25 to 50 per cent. higher than equally good lands, similarly situated, but not accessible by turnpike.

This fact shows that our preceding estimates of the losses by bad roads are much too small. Building a turnpike does not make the adjoining lands produce larger crops. It enables these crops to be marketed at better prices and less cost. If, then, a farmer finds that he can afford to pay 50 per cent. more for farms which have turnpike outlet to market, it is because on account of the cheapened cost of hauling and better command of the market he is able to add more than 50 per cent. to the income derived from the farm.

In those portions of Ohio which have taken advantage of the statutes provided, 50 per cent. increased value is not uncommon, and 25 per cent. is the least estimate placed upon such difference of location. Moreover, the people of those sections would not be deprived of their good roads at any price; nor would they consent under any circumstances to go back to the old system of mud roads. They pay their road tax in cash cheerfully, and without any longing for the annual picnic, commonly called "working the roads," which they formerly regarded as an inestimable right, and a glorious holiday, second only to the Fourth of July and Christmas.

Mr. Satterthwate, of Montgomery county, Pa., in an address before the Board of Agriculture at Bloomsburg in December, 1885, is reported as saying: "We find it pays to macadamize the roads, and our people would not like to be restricted to a tax of seven mills, because sometimes we want to spend a great deal more than that. We have learned that it pays to make good roads no matter what they cost. Everybody says 'if you will make the roads good we do not care for the tax.' It is when you have nothing to show for the money expended they complain, which is the objection to this working out system."

Any enterprise which reduces cost of transportation of crops and merchandise 40 per cent., adds to the annual income an unknown large per cent., and increases the value of land 25 to 50 per cent., should commend itself to the self-interest of every farmer in the State. It would be difficult to devise any scheme that would contribute so largely to the general prosperity as a large and immediate outlay, judiciously expended in the construction of first-class roads.

The road tax annually collected in the county of Allegheny amounts to about $140,000, and for the entire State, according to the best estimate obtainable, it amounts to the enormous sum of about $4,000,000. What have we to show for it? What a comment on the present inefficient methods these figures afford, in view of the condition of the roads at the present time.

We offer the following and respectfully present it to the Legislature of Pennsylvania, and recommend its passage.

T. P. Roberts,
T. H. Johnson,
A. Dempster,
C. Davis,
A. Kirk,
Committee.

AN ACT

To provide for the Location, Opening, Vacation, Construction and Maintenance of Highways, Roads and Bridges in the Several Counties of the Commonwealth.

Section 1. Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania in General Assembly met, and it is hereby enacted by the authority of the same, that it shall be the duty of the Court of Common Pleas of the respective counties within this commonwealth, to appoint a board of four persons, who, with the county engineer or surveyor, shall be constituted a commission to classify all the thoroughfares in the county, not included within corporate boundary lines, and to divide the same into three classes, to be styled, respectively, highways, roads and lanes. "*Highways*" shall include all those radiating from the county seat to other populous points in the county, or to the boundary lines of the county, and those connecting such other populous points; or those which by reason of their connection and extension in the same general direction, afford a continuous line of travel between such centres or to such boundary lines. "*Roads*" shall include all thoroughfares now designated as township roads, and which may not be classed as highways under this Act. "*Lanes*" shall include what are now styled "private roads" and which are used only for ingress and egress from roads or highways to individual property.

Sec. 2. Said court shall make such appointment within thirty (30) days after the passage of this Act, and it shall be the duty of said persons so appointed, to meet at the county seats of their

respective counties and organize by electing from their own number, a president and secretary, and shall then proceed without delay to make such classification, designating the several roads belonging to each class, and report their findings to said court. The classification thus made by said commission or a majority thereof shall be taken as final and conclusive in the matter, and the highways, roads and lanes thus designated shall be taken as such by all parties affected thereby. The compensation to be paid to said commissioners shall be fixed by said court, and paid by the county treasurer as other salaries are paid.

SEC. 3. In every township of this commonwealth, the qualified voters thereof shall on the third Tuesday of February, 1890, elect one person to serve for one year; one person to serve for two years; and one person to serve for three years, who shall be styled "road directors;" and at each annual township election thereafter, they shall elect one person to serve for three years; *provided*, that in any township which has now three road commissioners, no new election shall be required, except at the times of expiration of the terms of such incumbents; and *provided*, further, that the persons so elected as road directors, shall have been citizens of the township in which they are elected during the three years immediately preceeding the date of such election, and shall be freeholders in such township at said date.

SEC. 4. In case of any vacancy occurring from any cause, it shall be filled by appointment by the Court of Common Pleas of the proper county, until the next succeeding election, when the vacancy shall be filled by the electors of the township for the unexpired term.

SEC. 5. It shall be the duty of said road directors to meet on the second Tuesday of March, 1890, and annually thereafter, at the place where the auditors of the respective townships meet, and after being duly sworn by a justice of the peace to perform the duties devolving upon them by virtue of the provisions of this Act, they shall organize by electing one of their number as president, and one as secretary, and shall proceed to levy tax of not more than seven and one-half ($7\frac{1}{2}$) mills on each dollar of the valuation made by the township assessors for county purposes,

and shall certify to the county commissioners and county treasurer the amount of such levy; the same to be collected by said treasurer as other taxes are collected and to be set apart and kept as a road fund, which shall be paid out by him, on requisition of the county engineer, duly approved by the president and secretary of the road directors.

SEC. 6. The road directors, in conjunction with the county engineer, appointed as hereinafter provided, or his deputy or assistant, shall divide the township into road districts, and determine the prices to be paid per day for labor, the amounts to be expended in repairs and in permanent improvements during the year, and the amount to be expended in procuring materials, tools, or machinery deemed necessary to macadamize or otherwise improve the road; *provided*, however, that not less than thirty (30) per cent. of the road tax collected in each year shall be expended for materials to macadamize or otherwise improve in a permanent manner.

SEC. 7. The road directors, in conjunction with the county engineer, his deputy or assistant, shall have power to locate and open new roads, vacate existing roads, or change the location of the same, upon the petition of not less than six (6) taxpayers of the township in which the road is located, whenever they, or a majority of them, shall deem it necessary for the convenience or safety of public travel so to do.

SEC. 8. Upon receipt of said petition the said road directors shall notify the county engineer of such fact, whose duty it shall thereupon be to cause a survey to be made of the same, and make the necessary plans and profiles to show alignment, gradients, and lines of property affected thereby. In locating or changing such road he shall be governed: 1st, by ease of gradient; 2d, by directness of alignment; and, 3d, by least amount of damage consistent with public utility.

SEC. 9. The road directors and the engineer shall then be constituted a board of viewers in the case, and shall proceed at once to give notice in writing, delivered by messenger, to the property owners interested, where that can reasonably be done, and by hand-bills posted along the line of the road so proposed to be opened, vacated, or changed; said notices to designate a time not

less than ten (10) days from the date thereof, and a place on the line of said road when and where they will meet to perform the requirements of said view. They shall then and there, after hearing all parties interested therein, decide as to whether or not the prayer of said petition shall be granted. In case of a tie vote the decision shall be left to the Court of Common Pleas of the proper county, whose decision, after hearing the statements of the said board, shall be final and conclusive in the matter.

SEC. 10. In all cases wherein an affirmative decision shall be reached, the said board shall proceed to estimate the damages and benefits to each party in interest, and shall cause a schedule of the same to be made, showing the names of all persons assessed and the amounts of damages or benefits, and shall notify each of said persons of the amount with which he or she is charged or credited, as the case may be. They shall file said schedule in the office of the county engineer for ten (10) days from the date of such notice, during which time any person who may be dissatisfied with the amount of damages awarded or benefits assessed may appeal to the Court of Common Pleas of the proper county relative thereto, but such appeal shall not prevent or retard the opening and use of such roads; and the finding of the board shall be final and conclusive as to the necessity for and location of any new road; as to the propriety of vacating either in whole or in part any existing road; as to changing the location of any existing road; and as to all matters relating thereto, except only the amounts of damages awarded or benefits assessed. The Court of Common Pleas, upon appeal as aforesaid, shall have jurisdiction in the case, with power to approve, amend, or to set aside the findings of said board as set forth in the schedule aforesaid, and to order a review by a special board composed of the road directors of another township with the county engineer; and the findings of said special board shall be final and conclusive upon all parties interested. The cost of such views shall be considered and taken as damages, and be assessed as such, and where the damages exceed the benefits the excess shall be paid out of the road fund of the township.

SEC. 11. After the final decision of the case, or after ten days, if there be no appeal, the county engineer shall file the schedule

in the office of the county treasurer for collection, the same to be collected as other taxes or debts due to the county are collectable.

SEC. 12. It shall be the duty of the supervisor of the district in which any new road is located or existing road changed, as herein provided, to proceed to open the same within ten (10) days after the decision of the board relative thereto, and to place the same in safe condition for public travel, under the direction of the engineer, as soon as practicable.

SEC. 13. The width of all highways shall not be less than fifty feet, and of roads not less than forty feet; *provided*, however, that all existing roads and highways which have been established of greater widths than herein provided under the provisions of previous statutes, or which have been constructed by incorporated companies, and have passed to public control by lapse or surrender of charter, shall be maintained at the widths so first established.

SEC. 14. The said road directors shall each receive as full compensation for their services the sum of two dollars and fifty cents ($2.50) for every day employed in the performance of the duties prescribed by this act, which sum shall be paid out of the road tax fund by the county treasurer on the warrant of the president of the board, fully attested by the secretary, by affidavit that such time has been actually employed in such duties.

SEC. 15. It shall be the duty of the county commissioners to take cognizance of the classification so made, and to levy an annual highway tax on all property in the county not exceeding seven and one-half ($7\frac{1}{2}$) mills on each dollar of valuation made for county purposes. Said tax shall be collectable by the county treasurer as other county taxes are collected, and be paid out as hereinafter provided.

SEC. 16. The county treasurer shall set aside seven and one-half ($7\frac{1}{2}$) per centum of all taxes collected in the county for state purposes, which, together with the highway tax levied and collected as aforesaid, shall constitute a highway fund, to be applied to the permanent improvement and repair of the highways so designated, and of all bridges constituting parts of such highways.

Said fund is to be paid out on requisition of the county engineer as hereinafter provided.

SEC. 17. The county commissioners and the county engineer shall constitute a board for the improvement and repair of all highways and the bridges thereon. It shall be the duty of said board to determine the amount and character of work to be done on each of said highways in each year; *provided*, however, that not less than forty (40) per centum of the highway fund shall be expended in macadamizing or otherwise permanently improving the same. They shall, by advertisement in papers doing the county printing, solicit proposals for the furnishing of all materials needed, and shall let all contracts to the lowest responsible bidder.

SEC. 18. It shall be the duty of the Court of Common Pleas of each county of the commonwealth to appoint on or before the first day of January, 1890, and triennially thereafter, a competent civil engineer of at least ten years' experience as such, to be styled "the county engineer," and to serve for a term of three years. He shall give a bond in the amount required of, and shall receive the same salary paid to a county commissioner in the county for which said appointment is made; *provided*, however, that in every county in which there may now be a county engineer of said qualifications, no appointment shall be made until the expiration of his term of service.

SEC. 19. It shall be the duty of the engineer to make a map showing the location of all the highways, roads, lanes, and bridges in the county, together with their gradients; make all surveys for new roads and highways, and for changing location of existing ones; prepare plans and specifications for all work on highways, roads, and bridges; make and execute all contracts relative thereto, which may have been authorized by the board of highways or by the road directors; have supervision, direction, and control of all work in connection therewith; arrange with the road directors for the execution of all work decided upon by them; and appoint such supervisors as he may deem necessary to oversee the work and have it properly executed according to his direction; said supervisors to be citizens of the township for which they are appointed

and to have practical knowledge of road making. He shall make such rules and regulations for the guidance of the supervisors as he may deem necessary and have the same printed and distributed to the road directors and supervisors.

SEC. 20. The county engineers shall certify to the county commissioners, monthly, sworn and detailed statements of the amounts severally due for labor and materials expended upon the highways of the county, under contracts then in force, and the names of persons to whom the same may be payable, which statements, when approved by said commissioners, shall be sent to the county comptroller, who shall issue his warrants to the county treasurer, payable to bearer. The county treasurer, on presentation of such warrants, shall pay the same to the bearer thereof, and charge the sum so paid to the highway fund or to the road fund as the case may be.

SEC. 21. The county engineer shall, at the close of each fiscal year, make a detailed report to the county comptroller of all work done on highways, roads and bridges throughout the county, setting forth the number of miles of highways and of roads improved during the year and the cost thereof; the number of miles of highways and of roads previously improved and the cost of repairs thereon during the year; the number, location, and lengths of bridges built during the year and the cost thereof; the number and aggregate lengths of all bridges previously existing and the cost of repairs made thereon during the year; the number and length of roads or highways opened, vacated, or changed during the year and the cost thereof; together with a full report in detail of the condition of the roads and highways at the time of the report. And shall send a copy of the same, together with a copy of the road map of the county, to the surveyor-general, whose duty it shall be to make a connected plan of the highways of the several counties of the commonwealth; and shall make a summary report of the whole annually.

DISCUSSION OF REPORT OF COMMITTEE ON ROADS.

T. P. ROBERTS: I would like to state for the information of the Society that our report is not in the shape we desire. It is a

report merely of progress, but this Committee, if the Society wishes, will continue, adding any suggestions that may be given by the members. The proposed bill must go to Harrisburg before the next meeting.

WM. THAW, JR.: I would make a motion to the effect that the Committee get their bill into final shape and send it to Harrisburg. I don't think we have time to discuss it now.

ARTHUR KIRK: The accompanying paper shows the vast importance of the matter. The statements made cannot be disputed. Every taxpayer and every resident of the State knows that the road laws should be amended.

A. E. HUNT: I would like to ask of the Committee what exactly are the proposed changes that they wish to recommend in the improvement of roads. One or two that I thought of were the change of the grades and the shortening of the routes and, in some cases, the macadamizing of the roads. They did not suggest the macadamizing of all the roads. What was the idea of the actual time that they want to have put on the roads. Was there any direct plan suggested by them? If so, I did not get it.

T. P. ROBERTS: It is there. I would like to tell Captain Hunt that the laws of Pennsylvania are a complete blank on the subject of roads. So far as our Committee understands the legislation it refers the matter to the township authorities. There are about 30 townships in each county, and as referred to in the paper, it very often happens there are poor townships between two large towns and these towns have not the authority to make a road across such district. This classification of roads is a good thing, the idea being to provide for the great thoroughfares from a general county fund, while the township roads will be built with money obtained from the local tax of each district. That is the great revolution proposed in the law. The same point has been embraced in other acts suggested at Harrisburg, but ours goes much further in the directions of management, etc.

WM. THAW, JR.: Is there anything in that bill which gives the general supervision of the main roads between towns to the supervisors? As I understand it they take the county roads.

A. DEMPSTER: As the law is now, the supervisors are elected by the people. The people work out their taxes on the road and make it the occasion of a general jollification, with but little work. This bill provides for putting all the work under the direction of three road directors. The engineer shall appoint supervisors who must be experienced in road making; men of good common sense, working under the supervision of the engineer.

The classification of highways designates the roads that will be county roads. They are under the control of the county engineer and the county commissioners, who shall make application of the funds for the purpose of their improvement—those produced by the county taxes. The funds for the improvement of the township roads are produced by taxation of the township itself—a local taxation for local improvement.

Then there is the opening of roads. As it now stands, the law permits the road to be laid down on the ground that satisfies the views of the people. In this case the engineer shall be the judge and shall first have the road laid out, establish the gradients and then the alignment, and it don't make any difference whether it suits the people who petitioned for it or not. It is laid on the best grade and the best ground and then the people can submit their appeals as to the amount of damages or benefits they may be assessed.

T. P. ROBERTS: That is just the same as railroads.

J. REESE: I was wondering about the railroads and how they were going to be affected by this. It is a good thing to have the assessment on the county for county roads and on the townships for township roads, and both constructed under the direction of an engineer and the proper authorities. Now, railroads are going to be benefited by this movement very largely. Do you provide for the assessment of railroad property in making these roads?

A. DEMPSTER: Whatever property they have assessable will be assessed.

J. REESE: How is it with the country districts?

T. P. ROBERTS: They will, under this bill, be assessed as elsewhere.

A. DEMPSTER: Not the tracks, but all the property will be assessed.

J. REESE: What do you call property? Nothing but the right of way?

A. DEMPSTER: The right of way has by law been made non-assessable.

A. E. HUNT: Col. Roberts did not understand my question exactly. My question was to this effect: Is there anything provided in this proposed bill and in the talk about it in this paper of the specifications for the improvements of roads. That is to be left, you say, to the county engineers. One may have an idea to build with clay, another with quicksand, and others have different ideas. How do you provide for uniformity?

A. DEMPSTER: The county engineer is the head. He gives all directions.

After discussion, on motion the Committee was instructed to prepare and forward a copy of the Act to our representatives in Harrisburg and ask for its passage.

After which Jno. A. Brashear gave a lecture on

OPTICAL GLASS.

I shall give you a little prelude to this talk on optical glass by quoting part of a paper which was read by a gentleman before the Physical Section of the American Association of Science, at their meeting in Cincinnati, in 1881. I read it to you to convey this impression, that a man had always better understand a little about what he is going to talk upon when he commences.

The writer states: 1st. That the admixture of silver improves the quality of glass.

2d. That large lenses can be built up of cemented bars of optical glass.

3d. The writer essentially ignores the most important factors in optical glass, and indeed treats the subject in apparent ignorance, theoretical as well as practical, so much so that it is astonishing that such a paper would find a place in the annals of the American Association of Science.

I have had propositions from some of the manufacturers of glass in our own city in regard to making optical glass, and as its demands are so much more rigorous and exacting than the best

glass we are making from day to day for commercial purposes, a few notes on the subject may be of interest to our Society, some of the members of which are to be counted among the most advanced glass workers in this vicinity.

In a description of the methods of making optical glass, I shall necessarily have to be very brief. I presume the most of you who have read anything about optical glass at all, know that Guinand, of Switzerland, was the first to make it in large quantities, and it is said that his discovery was made accidentally. He was hauling some glass intended for optical purposes in a wheelbarrow one day, when it upset, and the lump of glass rolled out and broke, annoying him very much because he was hoping to get something fine out of this glass. However, he selected some of the best pieces and melted them down in a prepared mould and this was the germ of the method of making optical glass, as made at the present day.

Chance's method is something like this: They select their material as pure as possible, melt it in a single-pot furnace, in a single pot, and having melted it very thoroughly they introduce a stirrer, sometimes a platinum one, though usually a clay stirrer. After the material is thoroughly melted the stirrer is moved around in the pot until the glass becomes very thick. The furnace is then heated up again and the glass made soft and stirred until the impurities are worked up as thoroughly as possible. After the impurities have been worked to the top, which takes considerable more time than the ordinary melt, the top is skimmed and the furnace is luted up and allowed to cool; the walls being very thick this requires a very long time. After the furnace is cool a portion of it is taken down, the pot is taken out and the outside broken off entirely. Four, five or six places are ground and polished on the face of the metal, and it is examined with a tourmaline lens for defects. In this way they discover the good parts and cut out whatever discs they can get, and in some cases they find very excellent pieces.

The process used by Pfeil, at Paris, is somewhat different. I visited both of these works while in Europe. They melt their glass in large pots, which after slow cooling are broken off the glass, the glass usually being formed more or less broken. They

examine the pieces very carefully with tourmaline lenses and diffuse and select the best, which they re-melt in moulds made of clay. Great difficulty is experienced in making large lenses. The 36″ lens for the Lick telescope required no less than 19 melts, using a great amount of material.

Mr. Mantois told me the final process was something like this: Having found a lump which gave evidence that a good disc could be made out of it large enough for the purpose desired they examine it very thoroughly in order to find stria, or whatever defects may be in the glass. They then carefully grind these out.

For instance (illustrating), here is a lump of glass, irregular in shape, like this, and here is an impurity in the interior. They go to work and grind until they have taken out the imperfection. Understand, now, I am talking about the most perfect optical glass.

Mr. Mantois had in his shop a piece which he said would likely turn out the largest piece of perfect optical glass in the world, and which will be exhibited at the Paris Exposition. It will probably be large enough to make a 40″ lens. It would take him three or four months to grind out the imperfections, because in doing this they must be very careful, for the glass is liable to shatter from the molecular strain in it. No one has ever been able to put glass in such condition that there will be no molecular strain in it whatever. These lumps are then put into a mould of whatever shape they are to be made. The glass must be brought to a heat very slowly. In the first place a clay base is made like this (illustrating) and a clay ring is set on the top of it, made of very fine clay. That ring, in the case of all large lenses, is split into two parts, and a wire is wrapped round it three or four times, simply to hold it together.

When working this glass the temperature is brought up very slowly until it is very little above a red heat.

Now comes the critical operation of tempering the glass, that is, of allowing it to cool so slowly that each molecule, or each crystal, or whatsoever you may choose to call it, shall get into its normal or natural condition.

After the furnace has been brought to the heat which will allow the glass to settle, they lift off the "muffle" or cover and draw

the disc toward the mouth of the furnace. By critical examination it can be determined whether there are any impure particles in it which can be cut out. They reach into the pot and pull up the glass with a pair of long-armed shears and keep pulling it up carefully until the impurity is reached, when it is cut off by the shears. When this is done it is very necessary that the place chipped off shall fall back upon the top of the glass without overlapping, because if it does, stria is almost certain to form in the spot. One trouble in getting glass absolutely free from stria is that the clay of the pot melts off into it, which glass men understand more about than I do. In the case of flint glass it is one of the most difficult things they have to contend with.

After the impurities are eliminated as far as possible the furnace is allowed to cool for two, three, four or five weeks, sometimes as long as three months, in order that the glass should be perfectly annealed. At Jena, however, they melt down the discs in moulds inside of a heavy copper vessel in which a stream of gas is allowed to play, and this stream of gas is regulated by an automatic regulator, and in that way they have produced some of the best annealed glass that I have ever seen, indeed, my assistant, Mr. McDowell, is so biased in favor of the Jena glass that he is hardly willing to work any other. I have here a number of specimens of the Jena optical glass. You will find them quite transparent and free from color, as is quite marked in these specimens.

(Mr. Brashear here exhibited several specimens.)

This, then, is the method of making large discs. The ordinary "discs," however, are melted in square moulds. Some of them are ground and polished on the faces, and warranted when they find them absolutely free from defects; and I will call your attention now, very briefly, to some of the defects of optical glass, and which may be interesting to some of those who are interested in glass-making of any kind.

Here is a fine piece of glass made on the South Side, and is much clearer than some made in Paris. But it is imperfectly annealed. A glass manufacturer, who has gone to his rest, a very excellent man he was, too, Mr. John Adams, once said to me: "How can you tell when glass is annealed?" I told him it would

be a very unfortunate thing if an optician could not tell when the glass was perfectly annealed, because in the case of large lenses you may put two or three or four or five thousand dollars' worth of work on them, only to find the glass useless from imperfect annealing. Fortunately, in the action of polarized light, we have a means of determining the condition of glass. I have here a piece of glass, which was made by Chance Brothers & Co., which was purposely left unannealed, and which can be examined after this little talk is over.

This piece of glass would be absolutely useless for an optical instrument on account of its imperfect annealing. Here is a little piece of ordinary plate glass which was annealed at Tarentum, and which shows no evidence of strain. I could make a very fair lens of it.

The next difficulty is that of meeting imperfections on the inside of the glass, which we generally call stria. Some people will take up a piece of glass, and will find many little bubbles, and think it would be absolutely worthless for an object glass.

In the case of the great Washington glass, I presume there are at least 50 bubbles, but they do not affect it in any serious way. They only produce a very small defraction, which I need not stop to explain. But with stria it is a very different thing. Recently we had a piece of glass in which this characteristic was so prominent we could scarcely see anything but stria. Indeed, much of the so-called optical glass we get in this country, which is used for camera lenses, for ordinary opera glasses, and for a great many of the small telescopes, is very impure on account of stria. Here is a very fair lens to the ordinary eye, and it is impossible for you, by looking at it, to detect the imperfections. In fact, the flint glass we got from the Jena people was usually so good that we did not suspect any impurities, but finally we found it was necessary to test every one they sent. This glass, which as a 4″ objective would be worth one hundred dollars if it were free from stria, is not worth anything as you see it, on account of the stria in the lens. The method of detecting stria is very simple. It is by means of the diffused light from a candle or lamp concentrated on the suspected lens by a good convex lens, and by its aid a child can detect stria.

There are other imperfections met with in glass, such as *unequal* density, *i.e.*, the thorough incorporation of all the particles, etc. It is absolutely necessary that in the process of manufacture every impurity be eliminated.

There is a way the optician has of eliminating an error produced by stria if it is not too prominent. Let us suppose that we have here a lens that has stria, not too prominent. We rub the glass with the tip of the finger on which rouge or peroxide of iron is placed, so as to get a "hole" in it which will throw the light that comes through the striated part from a direct line and diffuse it, so that when it reaches the focal plane it is quite harmless. This is the method the Clarks use in eliminating aberrations which they cannot cure in any other way. This method will do when the stria is small, but when there is a great deal of it in the glass, it is worthless for optical purposes.

In purchasing glass, you can buy the ordinary discs and run the risk of getting stria or not, the warranted discs costing so much that it is cheaper to buy the discs that are not warranted and get two out of six, than to purchase the warranted discs. But when we wish to get discs above four inches we always buy the warranted discs. The manufacturers always take these warranted discs, grind them roughly and polish them, examine carefully and test with diffused light. I had the privilege of testing a great number of large discs for lenses while at Chance Brothers. We have no trouble in getting rid of stria usually if it is near the surface of the glass, for then we can grind them out, but if the stria is in the centre of the lens we have to throw it away.

I see no reason why our Pittsburg people could not turn out optical glass as well as it is done abroad; we have the best material and the best fuel in the world, and we certainly have the brains and the enterprise,—if carried out intelligently,—but there is a wide difference between ordinary glass and that used for astronomical instruments.

Society adjourned at 10½ o'clock. S. M. WICKERSHAM,
Secretary.

APRIL 16TH, 1889.

SOCIETY met at their rooms, 8.15 P.M.

President J. A. Brashear in the Chair.

Vice-Presidents W. L. Scaife and A. E. Hunt.

Directors T. P. Roberts, C. Davis, William Metcalf, Max J. Becker, and thirty-five members and visitors present.

H. S. Fleming and C. H. Tebbetts were duly elected to membership.

A. E. Hunt read the following paper, illustrating it by a diagram on the blackboard:

ON THE TESTING OF METAL, AND TESTING MACHINERY; WHAT THEY ARE FOR; WHAT THEY ARE.

First, it is necessary to give some definitions.

A definition is a short description which shall include every possible case of the subject and exclude everything else.

Matter is a general name given to the substance which, under an infinite variety of forms, affects the senses or occupies space that has length, breadth and thickness.

Force is whatever produces or opposes motion in matter.

The great forces which produce the constantly changing form and position of matter are called:

Internal or Molecular Forces,

Attraction of Gravitation,

Heat,

Light,

Magnetism,

Electricity,

and one other, of which we know even less than of all the others, called Vital Force. Concerning the real nature or the "why" of any of these great forces, we are almost entirely ignorant. We say that they exist, because we see their *effects* upon matter, but whether they are merely properties of matter, or are forms of matter itself, are like the acts of creation, at present beyond the human ken.

Internal or Molecular Forces are of two kinds, those of Attraction and those of Repulsion. It is to only one of the four great divisions or kinds of Molecular Attraction, namely, Cohesion, that we have to consider to-night, for the other three forms of Internal Attraction, namely, Adhesion, Capillary Attraction and Chemical Affinity, do not enter directly into the quantities of Force measured by ordinary metal-testing machines.

Cohesive Attraction is that force which binds together atoms of the same kind, and it varies greatly in different substances accordingly as the nature, form and arrangement of the atoms vary; these modifications of the Force of Attraction, acting at insensible distances between the atoms of different substances, give rise to certain important properties in bodies which are called Elasticity, Tenacity, Ductility, Hardness, Brittleness, Malleability, Pliability and Flexibility.

It is the combination of these important properties in metals that give their chief uses in the arts. And it is to certain technical measures of some of these properties of metals that ordinary testing machines are designed to either pull specimens placed in them apart, or to crush the particles together, or to bend them, and have ordinarily a weighing or measuring apparatus to indicate the force necessary to accomplish the desired results upon the specimens.

The results of tensile and compression tests are usually calculated so as to be reported in pounds per square inch of section tested for the sake of uniformity in comparison. The results obtained from ordinary testing machines are technically called Elastic Limit and Tensile Strength, in tensile tests; and Crushing or Compressive Strength, in compression tests. In tensile tests, also, the amount of permanent extension, usually expressed in percentages in any given length, usually 8 inches in small specimens, is recorded; also, the amount of reduction of area of the specimen, usually expressed in percentages of the original area of the amount of reduction in the area in the specimens, is measured. These last two terms are necessary, for they are the measures of the flow of the metal, that is, of its ductility; and, as you all know, for most purposes for which metals are made, a certain

amount of ductility, which is the opposite of brittleness, is required; and for structural purposes as much ductility as can be obtained in connection with the necessary tenacity and hardness is wanted.

The elastic limit in tensile tests is the force or load required to stretch the specimen to the point where the increments of extension are no longer proportionate to the increments of load applied. It is usually determined by the drop of the beam of the testing machine, and by its remaining down through several hundred pounds increase of load occasioned by the considerable flow of the metal in extension at a point a little above the elastic limit. Another method of noting the point of elastic limit is to chalk the face of the specimen near one end, and to place one leg of a pair of locked compasses in a prick punch-mark near the other end of the specimen, to mark a line across the chalked face, and to note the strain at which the compass point marks a double or perceptibly broader line on the chalked face of the specimen. But these methods are at best crude, and the personal equation and limit of error due to inaccuracies of measurement often amount to several thousand pounds.

The latest designs of testing machines have an apparatus that plots the increments of extension as well as records the corresponding loads applied. Such apparatus, or those designed to measure by micrometer and electric bell attachments to the extensions, are the accurate methods of obtaining elastic limit.

The modulus of elasticity of a specimen of metal is the ratio of the product of the load applied up to the elastic limit, times the length, to the product of the area of the section, times the increment of extension. The data for it is obtained by the aid of the micrometer apparatus described above, by which measurements of extension are easily read to the ten thousandths of an inch.

The modulus of elasticity of wrought-iron ranges from 25,000,000 to 27,000,000, and of steel from 28,000,000 to 31,000,000 for soft steel up to about 40,000,000 for very hard steel.

The results of crushing tests are usually calculated to pounds per square inch, although the specimens are, for stone, brick and light material, 2-inch cubes, and in iron cylinders of from ½ to

¾ inches in diameter and 1 inch in length. The height of specimens for crushing test has considerable influence on the specimen to resist crushing. The forms of failure under the crushing test are by splitting, shearing, of sliding, bulging, by buckling or crippling, or by cross-breaking. Ordinary red brick have a resistance to crushing in pounds per square inch as follows:

Red brick, . .	800 pounds.
Limestone, . .	4,000 to 5,000 pounds.
Granite, . . .	6,000 to 11,000 pounds.
Sandstone, . .	3,500 to 6,000 pounds.
Brass, . . .	10,000 to 12,000 pounds.
Cast-iron, . .	100,000 to 150,000 pounds.
Wrought-iron, .	36,000 to 40,000 pounds.

Transverse tests for structual material are made ordinarily to show the amount of deflection under the given load and under given distance between bearings. For cast-iron it is also used to show the relative strength of the metal; and an ordinary test for cast-iron is: In bars of 1 inch square, and when supported by knife-edges 4 feet 6 inches apart, they should be able to carry a load of 500 pounds without rupture, and without a deflection of more than 2 inches from the centre.

The best forms of testing machines for practical use have the specimens strained between two heavy plates, the upper one being held stationary on four stout pillars, and the lower one being moved by means of straining-screws operated by nuts and gearing; the power being transmitted from a belt upon a pulley driving a main shaft which is attached to the gearing.

The component parts of the machine may be classified under three heads:

1st. The straining mechanism.

2d. The machinery for communicating the motion to the straining mechanism.

3d. The weighing apparatus.

The straining mechanism is an upper fixed plate supported from the base of the machine by four heavy, stout pillars, which

rise from the main platform of the machine. This upper plate, as well as the movable lower plate, has square central openings, in which are placed, in the best machines, ball and socket joints, and inside of this a set of wedges with the interior faces serrated to facilitate the gripping of the specimens. By means of ball and socket joints the specimens adjust themselves parallel to the line of greatest stress and a straight pull is thus secured.

Better forms of wedges of late, also, have the interior face convex, which assists in the centring of the specimen, as well as securing a firmer grip upon it. This, however, is not as necessary in machines having the ball and socket joint. Four steel straining-screws pass through the holes at the corners of the lower movable plate and through openings in the levers and bed-plate, and have at their base driving nuts which are attached to the movable gearing. The top of the movable plate is bolted to the ends of these screws. Feathers fitting into longitudinal slots cut through the heads of the screws prevent them from turning. They therefore either rise or fall, carrying the lower plate with them, as the driving nuts are rotated by the driving mechanism below.

The main platform of the scale to which the weighing mechanism is attached rests directly upon the short arms of the main levers of the testing machine, they in turn resting upon cast-iron pillars rising from the bed-plate itself. The main platform of the machine rests wholly upon the main levers, and any pressure upon this platform is directly transmitted to it. To keep it in position, iron bars run from the bed-plate through the four corners and are secured by nuts having thick rubber washers, which serve to take up the shock occasioned by the sudden giving way of a large specimen.

The four long driving nuts, which transmit the power from the driving mechanism to the four main screws of the machine, are held between a collar which bears against the bed-plate and an iron plate at the bottom of the box. Wedges enter below these plates, having long handles which reach beyond the box. By means of a screw-thread, cut on their ends and nuts turned from the outside, these wedges can be forced in so as to take up any undue slack the nuts may have.

Above, where the nuts tend to bind, they turn on conical steel rollers running between steel plates. The upper steel plates bear against the collars, which are separated from the bed-plates by rubber washers.

Each nut has a large geared wheel which engages the central pinion, and are all turned by it in the same direction. These gears engage in sets of two on opposite sides of the pinion, one set being placed above the other. Another gear, K, on the lower end of the central pinion engages the bevelled pinion on the shaft, which is turned by wheel, M.

Between the lower shaft and this wheel is placed the changeable speed gearing, O. A sleeve, P, sliding on the shaft, but turning with it, carries a large and small pinion, either of which can be thrown into gear by the means of a lever.

The power from the engine is transmitted by means of pulleys which are clamped to the main shaft of the machine by means of Frisbie friction clutches. Sliding on the shaft between them is a double cone, operated by the main lever, which starts and stops the machine. When this lever stands vertically, both pulleys turn on the shaft; on being forced over in either direction, one set of clutch-jaws is expanded by the cone, and the pulleys to which they belong are clamped to the shaft and a motion in either direction given to the machine.

By combining the changeable speed gearing, the pulleys and the slow-motion attachments, four different rates of speed can be obtained for motion downwards, and two for motion upwards, in the ordinary testing machine.

The weighing apparatus consists of levers transmitting the weights to a beam upon which the weight is slid along, as in ordinary weighing apparatus. The main levers are ordinarily three in number, but are so constructed as to act as a single lever. The middle one of these levers is longer than the others, and runs back to a point nearly under the rear screws, where it branches into two arms, each arm being forked to allow the passage of a screw. Knife-edges support the rear legs of the platform, while the lever rests on two knife-edges upon pillars rising from the bed-plate. This lever receives the thrust from the two rear columns.

The two short levers, which receive the thrust from the front columns, are of equal length and curve outwards, each supporting two of the four front legs of the platform upon knife-edges. Under the platform the three levers run parallel and they find their support in a stirrup suspended from the second multiplying lever. The second multiplying lever is placed above and parallel to the first, and is of the same class; the resistance being between the fulcrum and the power, which is transmitted from the short arm of the beam by the rod, *n*, to the knife-edge, *m*.

The strong iron frame-work encloses these levers and is secured to the box by a diagonal brace. From this frame-work rise the supporting and guiding arms of the beam. The guiding arm carries suspended from its short arm a balance weight. There is also a cylindrical poise, running on a screw, which serves to adjust the beam. The beam of the machine is graduated into thousandths of pounds, and is balanced for the load applied by a poise weight, which travels along the beam.

Power applied to the extremity of the beam is multiplied, in the 200,000 pound Olsen testing machine, 4,651 times by the levers.

Compression test specimens are crushed between the platform and the lower plate, or upon a suitable anvil placed upon the lower plate.

Where the ultimate resistance of a material for tension or compression is to be determined, one man can easily manage an ordinary testing machine. When the extensions inside of the elastic limit have to be measured, an assistant is needed in the measurement of the extensions; one man running the power of the machine and the weights, the other making the measurements of the extension.

The best forms of testing machines now in the market cost about:

$900 for the 50,000 pound testing machines.

$1500 for the 100,000 pound testing machines.

$3000 for the 200,000 pound testing machines.

Larger testing machines for pulling full-sized members of bridge structures are used by the bridge companies; the Keystone Bridge Company, of this city, having a machine of a capacity of 500,000

pounds; the Union Bridge Company, of Athens, Pa., having a machine with capacity of 1,000,000 pounds. These machines are all horizontal and have the specimens fixed in a strong head at one end of the bed-plate and the other plate connected with the arm of a hydraulic or steam piston; the strain being applied by the movement of the piston backward or forward in the cylinder. The measurement of the strain being, ordinarily, pressure gauges indicating the actual pressure per square inch upon the piston-head in the cylinder, and with the area of the piston-head being known, the actual strain can readily be calculated.

Discussion of Mr. Hunt's Paper on Testing Machines.

T. P. Roberts: I would like to ask what has become of the Government testing machine?

Mr. Hunt: At Watertown? It is still in existence. It is probably the best machine in the country. Mr. Metcalf has just interrupted me to say the best in the world, and I can readily believe it. The reason is that for a large machine it is so accurately balanced and free from friction. The forms of testing machines I have described are not the most accurate. You can readily see that there is less friction in a hydraulic machine than in a screw machine. The machine made by the Emery people, of which there are but a few on the market, is the best machine for scientific work upon small specimens, or where the strains for very small increments of load are to be measured. The only trouble with the Watertown machine is that it is impossible for any common body to use it. It is under Government espionage. No appropriation is made for its use, and if you send samples for testing you are lucky to get results in a year's time. It is an elegant machine, however, and is kept in good condition, but it might as well be rusting, for it does no one any good.

William Metcalf: I am very proud of that lecture of Mr. Hunt, but I wish he had gone on and defined some of the properties he mentioned, such as ductility, brittleness, hardness, etc., and we could have had some fun.

Mr. W. L. Scaife: I should like to ask Mr. Hunt, whether,

if he had two specimens of any material exactly the same, and tested them, say, one in two minutes, the other in four, he would get in both cases the same results for tensile strength and elongation? In other words, whether time has not something to do with the results of these machines?

A. E. Hunt: That is one great advantage of machines of this character over the hydraulic machine—the strain is put upon the specimen by means of the pitch of the screws and not by the increment of pressure due to the pumping. With this form of machine, where the load should be applied steadily, the impact does not enter into it as it would with the hydraulic machine, but undoubtedly you can get different results. The more constant the pressure is applied, the higher the tensile strength and elastic limit and the lower the percentage of elongation and reduction of area. Faster speed lowers the results in ductility and increases those in tenacity. Still, the machines will show a little difference. In this connection there is an old trick of the trade, that if your specimens are low in tenacity and you want to bring it up, you work the machine quicker.

W. L. Scaife: For very accurate work and for comparison of results should not each tester have his equation of error depending on his methods of operation?

A. E. Hunt: Undoubtedly. The thing is reduced more with the mechanical system than where regulated by hand-power.

Mr. Matlack: You do not seem to have understood the question. With the present pumps they put on hydraulic machines, where they have from 3 to 6 inch throws they get a perfectly steady strain. But as I understood the question it was whether in using these machines, the speed of the lower head at 2 inches per minute, and also at eighteen minutes to 1 inch, whether you would not get a greater flow of metal in the slower strain than in the more rapid strain. It has been demonstrated in practice that is the case, showing greater ductility but less tensile strength.

W. L. Scaife: Suppose you have a brittle metal, like cast-iron, cannot an inspector put the test-pieces in the machine so that he will get one result at one time, another at another, or so as to

bring a side strain on it, and reduce the tensile strength considerably?

A. E. Hunt: Yes, sir. That is one of the very important points with reference to the testing machine; that is, that the specimens are put in centrally, parallel to the line of strain. You get a shearing-strain the minute you put your line of power outside the central line or longitudinal axis of the specimen. It often amounts to a very serious error in getting the results of a specimen. This effect can be almost always told upon the specimen, if ruptured, by noting the lines of flow of the metal.

Wm. Metcalf: That may be a very good machine for buyers, but not nearly so good as the old-fashioned machine for sellers. The machine I was trained on was the old weight machine. It was run by a crank, and that crank was worked by an Irishman's arm. We had a minimum and maximum limit, and it took very little experience in that Irishman's arm to get the specimen to break in the right place. You could do the same thing on the present machines, but you would be caught at it.

T. S. White: Should there not be a standard rate of speed, or is there such?

A. E. Hunt: There practically is, but there is none specified in any of the specifications that I know of. At the same time, most inspectors are aware of these points, and they usually watch to see that the specimen is pulled in the way it should be, and with the normal speed.

Max Becker: There is always required, in testing specimens, a certain expenditure of force to overcome the initial friction; I know that was particularly the case in the older kinds of machines. Of course, the results in smaller specimens would be different from those with larger specimens that required greater expenditure of power to break it, while the initial force would remain constant. Is there any formula to equate this difference? There might be some way by which these smaller and less perfect machines could be adjusted on the basis of the perfect Watertown machine so as to get practically the same results for eliminating this initial force and get the amount required for an actual deter-

mination of the strength of the material on an equal basis for all sizes. Has the thing been brought to that degree of perfection?

A. E. HUNT: Not to the degree it ought to be, and yet to a very considerable degree it has been by means of the regulation of weights and careful records kept with reference to that point, and comparing with the Watertown machine. I have within the last two months started a series of these tests, made of open-hearth steel in $\frac{3}{4}$ round tests, which we are testing in such manner as to get the average of the matter upon the standard machines of the country. I have this matter under way, but not in shape as yet to submit, but expect to report to the Society upon this point later.

MR. MATLACK: In that same connection, the 200,000 pound machine placed in the Boston Navy Yard is so delicate that if you put a 2 pound weight on the platform the beam went up, although it was only graduated to 10 pounds; and if this 2 pound weight would do that, the error must be very slight.

T. P. ROBERTS: In your sketch you show that H is higher than H primor; did I understand you to say this?

MR. HUNT: Yes, sir. The sketch is not drawn to scale.

MR. KOCH: I would like to say something about testing machines. The trouble is they are far too slow. If this country means to handle its trade we must have machines that will work faster. In the old country, in one mill with which I was connected, we kept three machines, and with them was connected a large fitting and turning shop, with planers and millers. We tested night and day. We have pulled three tests in a minute, but twenty per hour was about the average. If we could not do this we could not keep up on our inspection. This country will have to come to the same thing. What I am looking forward to is a testing machine that will work very much quicker.

The machines we used were perfectly accurate. Our results were compared with those of the Government machine which were taken in 8-minute tests, and they were the same. If you pull a test very slowly it will give you one result; at medium speed it will give you another, and very fast indeed, pulling at the rate of three per minute, when the specimens get so hot you can't touch

them, you will get the same results as in pulling slowly. We had to test rapidly, for the consumers were dancing around there waiting for their plates, and under such circumstances the inspector has no time to take elastic limit or anything else. If it makes 60,000 pounds and 20 per cent. in 8 inches that is all they want. The machine we used was an hydraulic machine. The machine was worked with a lever. We did not take the elastic limit, only the ultimate strength, and the results we got were as accurate as those obtained on the big automatic machine.

MR. MATLACK: Was that a horizontal machine?

W. E. KOCH: Yes, it was a horizontal machine.

MR. MATLACK: Were the grips used the same or similar to those used here?

W. E. KOCH: There were no two pairs of grips alike. We tried every kind of grips. The testing department kept about fifteen men busy all the time preparing, measuring, and putting the grips and test-pieces into the machine. We had to work in this manner; for instance, when we got a 10,000 ton order for plates from the Government, of which 500 to 600 tons per week were wanted, and we had to test nearly every plate, there was no time to do anything else.

A. E. HUNT: There are advantages about that class of machines, for while, as a rule, what is worth doing at all is worth doing well, unless you have some rapidly working machine you cannot make as many tests as you ought to. The advantage is not in the accuracy of the test, but in the many more of them you can make. Two points are mainly wanted: that the steel is strong enough, that is, has a sufficient tensile strength to answer the purpose, and that it has sufficient ductility. Enough tests must be made to insure the uniformity of the material; to see that the manufacturers have not put in some rail carbon steel in place of good structural steel, for instance.

W. E. KOCH: They do not test every plate now. I think only about one in a hundred, because the manufacturers kicked. They could not go on in that way. It costs too much.

MAX BECKER: In making tests of iron I believe it has always been taken for granted that after testing a specimen up to a certain

extent, then resting for awhile, and then starting the machine afresh, that it would require a higher expenditure of power than was indicated at the time before resting. I would like to know whether there have been any experiments made to see whether that holds good in steel? I can readily imagine why it should be so in iron, but not why it should hold good in steel.

W. E. Koch: It will happen every time. I have tried it hundreds of times.

Wm. Metcalf: I know a better way than that; that is, not to test at all. We frequently get demands from various parties to get a certain tensile strength, elastic limit, modulus of elasticity, etc., and we simply write back to them the truth, that we don't know anything about it, but if they want us to, we will send them a piece of steel that we do not think will break.

J. A. Brashear: I would like to ask of these gentlemen who do so much testing this question: Suppose you test a specimen, do you know at all that the pieces it is to represent will be *exactly* like it? If they are not the same, is it necessary to go to so much refinement in testing machines? I find in my experience in working materials whose molecular condition I can see by optical means, that there are absolutely no two pieces alike. I have yet to find absolute homogeneity in any material made by the hand of man. If we only find approximation to homogeneity I do not know that such absolute refinement is necessary in tests of this kind.

There is another question that has always interested me, and the answer Mr. Koch gave was *apropos* to that question. I have often thought in the testing of boilers, is it not dangerous to test to the limit? In other words, are the plates as safe after testing as before? My attention was called to that at the time the little incline was put up to the head of our hill, where a heavy test was made on the bar of iron connecting the car with the wire rope. I asked the builders this question, but they could not answer it.

A. E. Hunt: That is just exactly the argument often used by engineers. A common way of testing a railroad bridge is to load it with engines, so the load will be quite up to the maximum load the bridge is calculated for. A danger is encountered here, that there may have been some parts of the bridge overstrained, that is, beyond the elastic limit.

You ask the question whether one test will represent the whole lot of material? No, we do not know that it will. There are very many exterior causes for failure, just as you spoke of with reference to your glass. It may have been handled incorrectly, or improperly worked, which would not be determined by the test, but as to structural material it is now made mostly of steel. Steel is cast either from Bessemer converters by "blows," as they are called, or in open-hearth furnaces by "heats." The steel is tested in lots, taking a given number of tests of each heat or blow; and in this way experience has shown that the steel is reasonably homogeneous, so far as certain qualities are concerned. If it is properly handled afterwards there is no trouble, but if the steel is wrong in the first place, the tests will show that point and will cause its rejection. It will not necessarily prove, however, because you have good tests that all the material is right.

WM. METCALF: Mr. Becker raised a point as to whether if you strain a piece to its elastic limit point and let it rest, whether by testing again it does not show a higher strength? Wohler's experiments show that is true. It does. Now, then, I want to ask if it is not true that in testing a boiler or bridge it is not stronger after a rest than it was before, unless you start an incipient rupture somewhere. If your structure is broken down by the test that is the best thing you can do, for it will save life probably afterwards. The same rule would apply to a boiler unless you test it to the point of incipient rupture, which no man would do. He would test only up to the limit of safe strain. And all experience shows that to be safe.

A. E. HUNT: With reference to a boiler I will admit the force of Mr. Metcalf's argument. With reference to a bridge it is different. It may be only thought that you are straining each member up to a point of 8000 or 9000 pounds per square inch, but do you know that all those bars are just one length? It is not sure, and it may be that you have actually tested one member more than it was calculated for, more than it ought to stand; and, that being the case, that member will go that much quicker.

WM. METCALF: I do not see it yet. If it is tested within the limit of rupture then, after resting, the tensile strength has been

increased, and what has been done has been good instead of harm. I do not see yet the objection to tests of that kind. If one bar takes too much strain it ought to be pulled out so as to allow the other bars to do their part of the work.

T. S. WHITE: Is it not the case where the second test shows no permanent set of the bridge that it is a sufficient demonstration that the bridge is not injured by the test?

A. E. HUNT: That would be a good test. It is usually called for in specifications that the load shall be applied twice.

MR. MATLACK: In that same connection I would like to call Mr. Metcalf's attention to what I saw in the testing-room at Watertown some months ago. They were showing results of tests made of material strained slightly beyond the elastic limit, but had not yet come to a permanent set. After a rest of forty-one months a further test of the material showed the same elastic limit it had previous to the original test, so that would seem to corroborate your illustration of the one eye bar in a bridge which had been strained a little beyond the elastic limit and did not break. After a rest it would be as good as the rest of the bridge.

Society adjourned at 10½ o'clock.

S. M. WICKERSHAM,
Secretary.

MAY 21ST, 1889.

SOCIETY met at their rooms at 8 o'clock, P.M.

President J. A. Brashear, Vice-President W. L. Scaife, Director T. P. Roberts, 30 members, and 5 visitors present.

The minutes of April meeting were read and approved.

Henry Aiken, of Homestead; John McDonald, of Pittsburg; J. J. Keenan, of Allegheny; George H. Paine, of Swissvale, were duly elected to membership, after which Louis J. Clarke read the following paper, illustrating it on the blackboard and showing the working with the instruments themselves:

THE PHONOGRAPH AND GRAPHOPHONE.

At this time it is interesting to recall the fact that the Assyrians and Babylonians, 2500 years ago, used cylinders of baked clay upon which to record their ideas and history.

These cylinders, while intended pretty much for the same purpose as those of the phonograph of to-day, differ greatly from them in one essential particular. Those of the ancients have to be translated by such learned men as Rawlinson and Layard, while the ones of the present day speak for themselves—the phonograph or graphophone acting as interpreter.

You readily understand that the characters inscribed upon the cylinders in both cases are visibly equally unintelligible. Several years previous to Edison's first discovery, Faber invented a talking machine, modeling his apparatus after the vocal organs of the human throat. This was truly a wonderful machine, but of no practical value, being too complicated.

At a somewhat later date, Leon Scott invented *his Phonautograph*, a machine by which he could record sound vibrations and make them visible, but in no way reproduce them. W. H. Barlow, F.R.S., adopted Scott's principle, made some modifications and improvements, and styled the instrument *the Logograph*, some enlarged tracings from which I will presently show you.

The principle of this machine, as described in Prescott's *Bell's Telephone* is this: "The logograph consists of a small speaking-trumpet, having an ordinary mouthpiece connected to a tube, the other end of which is widened out and covered with a thin membrane of goldbeater's skin or gutta percha. A spring presses slightly against the membrane, and has a light arm of aluminium, which carries the marker, consisting of a small sable brush, inserted in a glass tube containing a colored liquid.

"An endless strip of paper is caused to travel beneath the pencil and is marked with an irregular curved line, the elevations and depressions of which correspond to the force, duration, and other characteristics of the vocal impulses.

"The lines thus traced exhibit remarkable uniformity where the same phrases are successively pronounced."

As I do not intend to enter into a discussion upon acoustics, I will pass on to the history of the phonograph proper. It was in the spring of 1877, while Edison was experimenting with a machine that recorded Morse characters by indentations upon paper and automatically transferring them to another circuit, that he conceived the idea of recording and reproducing articulate speech. It happened accidentally, in this way: While manipulating the machine he caused the paper tape on which the dots and dashes were recorded to be passed very rapidly beneath the recording-needle, producing a humming noise, like that of muffled voices, he immediately realizing that the problem of recording and reproducing speech and other sounds was practically solved. All that remained was to make some modifications of the apparatus—fitting a diaphragm to the needle and using paper tape soaked in paraffine.

The results produced by this machine were really startling—so startling, in fact, that the civilized world was very hard to convince that it was not all a hoax.

After a short time the paraffine paper tape was done away with and a cylinder covered with tinfoil substituted in its place. A few of these old tinfoil squeak boxes were manufactured in 1878 and sent all over the civilized world on exhibition, at which time, or since, doubtless many of you had an opportunity to examine, so I will not stop to describe them here.

These machines purposely sacrificed distinctness of reproduction for loudness of tone. The same needle being used both for recording and reproducing the sound, the record being reproduced once, it was of no further use, as it was destroyed by the needle passing over it the second time.

From this time until within the past two years, Edison was so much engaged with his electric light, telegraph, telephone, and other inventions, that the phonograph was laid aside and almost forgotten, but never abandoned, as many people imagine. It had been Edison's intention, at some future day, when he had more time, to develop and improve his invention, and at last he succeeded in doing so. In the *North American Review* of May, 1878,

he published a paper on the phonograph and its future, predicting the future uses to which the phonograph would be put.

These predictions have now been verified and the machine is in actual and constant use, and it may be safely asserted that within the next two years the phonograph will be as common as the telephone.

The principle of the phonograph, the present as well as the original, is this: A cylinder of some malleable material, such as wax, celluloid, or soft metal, is caused to *rotate at a uniform rate of speed.*

This latter is absolutely necessary, as upon it depends largely the proper working of the machine.

In the original machine the cylinder, which had a screw cut upon its shaft, was caused to move longitudinally, the diaphragm remaining still; in the modern, the cylinder simply rotates, the carriage carrying diaphragms moving along in an exactly similar manner to that of a slide-rest on a screw-cutting lathe.

However, the result is exactly the same: the record is cut in a spiral upon the surface of the cylinder.

To the back of the recording diaphragm is fastened a needle of peculiar shape, which, when set in motion by the vibrations of the voice, musical instrument, or by other means, cuts indentations representing the vibrations in the surface of the cylinder. I imagine it would be a very interesting study to thoroughly examine these records by means of a powerful microscope.

But to return. The instrument is then reversed, and in the case of the new machine the reproducer is swung into play.

This is very similar to the recorder, the needle being of slightly different shape and not being so sharp, and the diaphragms being somewhat lighter.

This reproducing needle then takes up the exact position of the recorder, and as it bumps over the uneven track left by the latter it sets its own diaphragm in vibration similarly to that of the recorder under the action of the voice.

This, in short, is the principle of the phonograph, and it only remains for you to examine the instruments I have with me to-night to thoroughly understand their workings.

It is a rather difficult matter to give an intelligible description of the modern phonograph, but I will do the best I can to make you understand its mechanism.

In the first place, an electric motor of peculiar design is used in driving the cylinder. This motor is a multipolar machine with Gramme ring armature 10 inches in diameter, having 40 segments.

The great diameter of the armature makes it rotate very steadily, acting as it does like a fly-wheel. The resistance of the armature coils being so low, a current of only 2 volts is necessary to give it sufficient speed to rotate the cylinder properly. The motor does not depend wholly upon the inertia of the armature for its steady movement, but a small and very perfectly made governor is inserted in the circuit, cutting off the current in an exactly similar manner to that of a steam-engine governor.

By means of a thumb-screw attached to this governor, the speed of the armature may be changed at will.

A record should always be reproduced in exactly the same speed with which it was made. That is to say, if you make a record with the cylinder revolving 100 times per minute, the reproduction should be made with the cylinder travelling exactly at the same speed. Otherwise, the pitch of the voice, music, or other sounds will be changed—lowered if the speed is decreased, and raised if the machine runs faster. You can readily see the reason for this.

The main shaft of the phonograph proper—that which carries the wax cylinder—revolves at right angles to the armature shaft, and is connected to it by a belt.

In the early phonographs Edison used bevelled gearing to connect these two parts, but he soon found that the teeth of the gears gave the cylinder a slight vibration, which was detrimental to the perfect reproduction.

The carriage upon which the diaphragms are fastened is given its lateral motion by a nut pressing against a screw cut on the main shaft. This screw has 100 threads to the inch.

In the case with the graphophone the record is cut at the rate of 160 threads to the inch. In the phonograph the diaphragms are

made of glass, about $\frac{1}{500}$th inch thick and 1$\frac{3}{8}$ths inches diameter, the recording diaphragm being slightly heavier than the reproducing.

The diaphragms are set in metal cases, with their edges screwed between rubber bands, permitting them to vibrate most freely.

Edison experimented a long time upon different substances out of which to make his diaphragms, and at last determined that glass was the best, as not being affected by the weather, and being very elastic.

Until quite recently the point of the recording needle has been square, like that of an ordinary chisel, but within the last month has been changed to the form of a gouge, cutting a semicircular record.

This they find to be a vast improvement over the old style. Previously, the reproducing needle was simply a hooked piece of steel with a very sharp point. This more or less injured the record, so it has been replaced by a tiny steel ball highly polished, connected to an arm that is fastened to the diaphragm.

To the centre of this arm is pivoted, in a peculiar way, a weight that causes the reproducing ball to follow any unevenness in the cylinder.

The spherical shape of the reproducer permits it to fit snugly into the semicircular groove cut by the recorder.

For a long time the blank cylinders were made principally of beeswax, hardened slightly with other substances, but when the new needles were adopted this wax had to be discarded as being too soft. Just what the composition of the new wax is, none but the initiated (and I am not of that number) may say. However, it is very hard and brittle, and produces a very silky record.

By using this wax and the new needles nearly all the hissing sound that has been so annoying is eliminated; besides, the instrument is 100 per cent. more sensitive, a whisper being perfectly audible. In fact it seems to magnify the sound.

The Tainter & Bell graphophone is a very much simpler machine in its construction and operation than the phonograph, and for that reason it is easier to learn to operate.

But if a person will only take the pains to learn the functions

of the various parts of the phonograph, no trouble will be experienced in getting a perfect reproduction. In neither case is it as hard to operate as a type-writer, and a boy of ordinary intelligence can learn to handle a graphophone in ten minutes.

In the graphophone the cylinder, which is of paper 6 inches long and $\frac{1}{14}$th inch in diameter, and covered with a thin coating of black wax, is caused to rotate between two tapering chucks that press against it by means of a spring. The screw which moves the recorder and reproducer is encased in the guide at the top of the instrument, and is rotated by gearing from the main shaft—another case of the slide-rest principle. Both the recorder and reproducer are very simple in construction, in each case the diaphragm being made of mica. Ordinarily a treadle is used to run this machine, though any other source of power may be employed. The two machines differ in another very important feature. In the phonograph the carriage carrying the diaphragms rests upon two slides, between which the cylinder revolves. This carriage being so heavy is absolutely rigid.

Now, in the case with the graphophone, the diaphragm rests upon but one guide and upon the cylinder. By this arrangement the recording and reproducing needle follow any unevenness in the cylinder, so that it does not have to be so absolutely true as in the phonograph.

Another very interesting "talker" has been invented by Berliner, of Washington, the principle of which differs in many essential features from both of the instruments just described.

The substance upon which the record is made is a zinc disc rotated horizontally. This disc is first coated with collodion or some very thin varnish, which is allowed to dry.

It is then placed upon the instrument and given a steady motion by clock-work. The recording stylus does not produce indentations on the surface of the zinc plate, but is given a wavy motion similar to the logographic records previously shown you, and travels in a spiral from the periphery to the axis.

As the needle passes over the plate it removes, in a fine line, the varnish, leaving the metal bare. The disc is then removed from the machine, and with chromic or sulphuric acid the record

is etched, after which the operation is exactly the same as with the other machines. It is said by those who have had the good fortune to hear this instrument that the reproduction is simply overpowering, 10,000 people together being able to hear it with perfect distinctness. As you can readily see, this is not a practical business machine, but is more adapted for exhibition purposes.

But to return to the phonograph. Unlike the telephone, it is a complete machine in itself, not being dependent upon a central station and the number of other instruments in use for its value.

Then, again, the phonograph may be used in so many more ways than the telephone. Of course the two instruments should not be compared, as they have very different fields of usefulness; yet, to-day, many people smile when they hear the declaration that within a very short time they will be equally common.

To the person who has not given the matter very much thought, the phonograph appears to him only as a very amusing and novel plaything, and when the long list of its many applications is recited to him he is at first incredulous, and then begins to see how very short his sight has been.

Edison, in his article to the *North American Review* of May, 1878, gives a list of uses to which the phonograph would ultimately be put. This I here insert, with a few additions:

"1st. Letter writing and all kinds of dictation without the aid of a stenographer. 2d. Phonographic books, which would speak to blind people without effort on their part. 3d. The teaching of elocution. 4th. Reproduction of music. 5th. The 'Family Record,' a registry of sayings, reminiscences, etc., by members of a family in their own voices, and of the last words of dying persons. 6th. Music-boxes and toys. 7th. Clocks that should announce in articulate speech the time for going home, going to meals, etc. 8th. The preservation of languages by exact reproduction of the manner of pronouncing. 9th. Educational purposes, such as preserving the explanations made by a teacher, so that the pupil can refer to them at any moment, and spelling or other lessons placed upon the phonograph for convenience in committing to memory. 10th. Connection with the telephone, so as to make that invention an auxiliary in the transmission of permanent and invaluable

records, instead of being the recipient of momentary and fleeting communications."

When the instruments come into general use and all the principal hotels have them, what a boon it will be to the travelling men. Then the heretofore unhappy drummer may, for a small fee, send to his employer a verbal history of the day's operation, instead of having each evening to sit down and write home a long and wearisome epistle.

To the musical composer it will be almost an invaluable aid, for, while he improvises, all the harmony he brings from his instrument, which would otherwise be entirely lost to the world, may be recorded and transcribed at leisure.

The list of the various uses of these instruments is almost endless, new applications arising each day.

A secret process has been discovered by Mr. Edison by which a phonographic record may be reproduced 10,000 fold, so that shortly one will be able to purchase, for a very small sum, songs by our most noted singers, music from the celebrated performers, and speeches from the most famous oraters of the world.

Who would not be willing to pay one dollar for a cylinder containing a song from Patti—a song that you could hear not only once, but every day in the year?

To show you how much matter one of these cylinders can contain, two columns (2500 words) from the *New York Tribune* have been dictated to one graphophone cylinder, and a special phonograph, made by Edison, using a cylinder 8 inches long by 4 inches in diameter, four of which would contain the whole of *Nicholas Nickleby*.

I have endeavored to procure from the Edison laboratory some data in regard to number of vibrations in certain words, and other information of interest, but they have been too busy to furnish me with what I desire.

In conclusion, I would say that, having had so very little time to prepare this paper, I feel that I have not done the subject full justice.

In the course of his paper Mr. Clarke gave a description of a new invention by Mr. Edison whereby sound was reproduced not by a needle running over the indentations, but by a very highly-polished steel ball. The paper not fully explaining the point, the following interruption occurred:

W. L. SCAIFE: Does the ball turn on an axis?

L. S. CLARKE: The ball is solid. It does not slide over the record, but takes the place of a point.

W. L. SCAIFE: It does not revolve? Is it simply a spherical surface?

L. S. CLARKE: It does not revolve. It is connected to that rim on one side.

J. A. BRASHEAR: Suppose, in the cutting by the needle of the indentation effected by the action of the voice, that it would go down and then be raised up, would a spherical ball go down to the bottom? It does not strike me it would.

L. S. CLARKE: That is even so, and that is one point that I do not quite understand myself. I do not see how the ball can get into the sharp depressions.

T. P. ROBERTS: What is the diameter of the ball?

L. S. CLARKE: The ball, I should say, would be not more than $\frac{1}{80}$th of an inch, or possibly $\frac{1}{100}$th.

W. THAW, JR.: The ball must be less than that. It is practically a point, so far as the physical sensation is concerned.

L. S. CLARKE: The curious feature of it is that it works better than if it were sharp; and there is another feature of the thing, that there is a peculiar quality of the voice that is lost by the machine. It does not reproduce all the characteristics of the voice.

A MEMBER: What becomes of the shaving turned off by the gouge?

L. S. CLARKE: It is dropped into this box (showing on the machine). It comes off in the shape of powder.

After the conclusion of the reading of the paper, the following questions were asked:

A. DEMPSTER: Do you say you use mica in the diaphragm?

L. S. CLARKE: We use mica in the graphophone here.

W. THAW, JR.: You say that the glass you use is only $\frac{1}{500}$th inch thick?

L. S. CLARKE: Yes. (To another question.) It does break occasionally, though it is wonderful what amount of hard knocks it will stand.

W. THAW, JR.: What kind of glass is it?

L. S. CLARKE: I really cannot say.

After the Society had listened to some singing, reproduced,

T. RODD asked: How do they sing into it?

L. S. CLARKE: They sing right into the mouthpiece.

T. RODD: Is it in daily practical use?

L. S. CLARKE: Yes, sir; right in this city.

A MEMBER: For what uses?

L. S. CLARKE: Principally taking the place of a stenographer.

There was then reproduced the song "A Warrior Bold," by William Pruette, of the Emma Abbott Opera Company, which Mr. Clarke stated had been reproduced over 500 times.

L. S. Clarke also stated that he did not understand about the needle being so extremely sharp. He did not see why, in passing over the impression with the sharp point, such impression was not ruined.

W. THAW, JR.: The round ball will not take off the impression?

L. S. CLARKE: No; it does not destroy the record.

T. P. ROBERTS: Would not very loud noises while you were giving an exhibition have a reflex action?

L. S. CLARKE: Nothing is recorded unless the sound goes right into the machine. Yet I have dictated to the new phonograph in a hall at a distance of 12 feet.

J. A. BRASHEAR: You had the recorder in them?

L. S. CLARKE: Yes, sir; of course.

L. S. Clarke then reproduced some piano music, after which

A. DEMPSTER asked: How did you get the sound from the piano?

L. S. CLARKE: We have a large horn, which is placed near the machine.

The Society then listened to reproduction of music, etc., spending the remainder of the evening in this manner, adjourning about 10 o'clock.

S. M. WICKERSHAM,
Secretary.

JUNE 18TH, 1889.

THE Society met at their rooms at 8 o'clock, P.M., President J. A. Brashear in the chair.

Vice-President Scaife and Directors Roberts and Davis, with 47 members and visitors, being present.

After reading and approving the minutes of the May meeting, on recommendation of the board Walter C. Mellor was duly elected to membership.

A committee was appointed to report on the death of our late member, H. C. Dickinson.

The subject for the evening's discussion being

THE SOUTH FORK DAM,

Thomas P. Roberts opened the matter as follows:

It was mentioned in one of the papers that I would be prepared at this meeting to discuss this question, but that was made without consultation with me. I have prepared no paper, but will answer any questions I can.

There is one point I would like to correct, however. I was reported as saying, after visiting the dam, that the rainfall had nothing to do with the breaking of the dam. I want to have that corrected. I wish to say that there was, undoubtedly, a great deal of rainfall connected with it,—a cloud burst,—and the evidence of that is, I think, unimpeachable. The fact that a lake of possibly 500 acres rose in a few hours to the height of 7 feet 3 inches above its ordinary level, with, at the same time, its waste weir discharging to the utmost of its capacity, is evidence that there was a great deal of rainfall.

I would like to have information as to the area of that basin. It is a very interesting point yet to be determined. A committee has been appointed by the American Society of Civil Engineers to make a thorough survey, including the water-shed, and we may expect definite information on completion of their work.

In the edition of the *Engineering News* of the fifteenth of this month, Mr. Wellington, one of the editors, reports that the top of the dam was 18 inches lower than the end against the bank. This was in a distance of 300 feet, and taken with a hand-level. I am inclined to think such a measurement very uncertain; nevertheless, he has built up quite a theory on that. From his statements it would seem that the amount of water flowing through the waste weir was only about 4½ feet deep. Now, it is positively certain that the lake rose fully 7 feet above the level of its low-water outlet, and, as the weir is at one side of the lake, it must have been 7 feet deep entering that place. The depth of water, so far as I could understand from the testimony of those who were present at the time, overflowing the dam was about 10 inches to 1 foot, and I do not think the sag could have been over 15 inches, or, at greatest, 18 inches, instead of 4 feet. Of course, when levels are taken, my figures may be changed. The width of the break in the dam I made to be 372 feet; it may be somewhat more.

W. G. WILKINS: Mr. Park informed me that they raised the embankment about 1 foot at the centre point; that the water began to go over the dam about 12 o'clock, and the dam broke between 2 and 3 o'clock. He walked over the dam at 12 o'clock himself. There was about 2 or 3 inches going over the dam at that time. Between 2 and 3 o'clock the front face of the dam was washed away so much that the pressure of the water back of it broke out a piece about 10 feet wide and 10 feet deep. From that time, he says, it was about 45 minutes—another gentleman says an hour—before the entire break took place.

T. P. ROBERTS (after making a sketch from memory, on the black-board, of the dam and the break), illustrating: This represents the road coming in from South Fork, passing right over the dam, or did before the dam broke. The break is 372 feet wide. In the ordinary stage the depth of water is about 62 feet, and total height of dam from foundations 75 feet.

The waste weir is here, and a bridge went over it. The interior slope was rip-rap, but here there was a piece of hand-laid wall. Here is the tower, built in the old canal times. The masonry foundations of that tower are now visible.

I made a cross-sectional sketch of the dam here, showing the stratification very distinctly, in layers of 6 inches to 1 foot. I do not think there was any place where these layers were over a foot thick. It is a little wavy, but very compact. Then there is a portion on the lower slope which does not seem to have been made with the same care, nor was it necessary. There is a great deal of rip-rap on the lower slope; I suppose 10 or 15 feet deep at the bottom. This part here, in the lower slope, seemed to be shaly earth. The entire upper half was a puddle wall. That puddle wall at the base was not less than 160 feet, rising to the upper edge of the road. I may say that none of the material that was last placed in the dam is remaining there now. I think I can speak positively as to that, because the statement has been made that 22,000 yards were required to fill the old gap, whereas, by my rough measurement, I found that about 100,000 cubic yards of material were removed from the dam. The original cost was about $17,000. It would cost now over $50,000 to repair the dam.

This puddle is well made and the dam was certainly intrinsically strong enough to resist any pressure. The trouble was from overflow. I understand from the statements of those on the ground it came over in a distance of 200 or more feet and about 10 inches deep. The washing away continued until only about 5 feet of that road remained, and then the pressure became too great for what was left to hold back the water. It is difficult to ascertain the time the water was passing out, because in their excitement they could not tell exactly; the statements vary from one-half to one and a half hours. One reason, I think, it took considerable time to flow out was, that the water was 70 feet deep at the time of the overflow, and the water was not probably over 30 feet deep just below the dam after the break. The section of the break was wearing deeper all the time, of course. So also was its capacity for discharge diminishing.

In regard to this waste weir, it is reported that it was very much obstructed, but I did not find that to be the case.

They told me that the water in the creek was unprecedentedly high all that morning, so I think the weir was discharging very freely. It must be remembered that the reason the marks are not distinct about this weir, is that the water was clear all the time it was discharging. (Mr. Roberts illustrated very freely from his sketch.)

Below the dam I noticed an immense bar fully 1500 feet long, from 5 to 12 feet high and 160 feet wide. It contains approximately 100,000 cubic yards of material. I was told by a gentleman familiar with the valley below, that it was a new deposit of material since the accident, so that it appears all this material has come from the dam.

A great deal could be done in the way of determining the quantity of water which fell. The rain began falling the previous evening. There had been a pretty hard shower in the afternoon, but not of very great length. About dark it began again and rained continuously throughout the night. A statement was made in the Pittsburg *Post* by a party who had been up there, giving a graphic description of the way those streams had risen, due to the tremendous cloud-burst. Little streams ordinarily only six inches deep had come up 5 to 6 feet, actually cutting earth from the hillsides, tearing holes in the ground, etc.

Now, if we had the area of that lake and calculations of the weir from the time it began to rise, we could get a very good idea of the amount of water that fell in the entire valley. Although, as the lake was still rising at the time of the break, the calculations will have an element of uncertainty about them.

LEWIS S. CLARK: I have no data except in regard to the dimensions of the lake. By actual measurement, made February 18th, 1888, the length, measured down the middle, was 10,188 feet, 1.93 miles. The line was kept out about the middle all the way down. The breadth opposite the lower end of the boat-house was 1734 feet, .32 of a mile.

W. G. WILKINS: Since the bursting of this dam I have been looking up the subject of dams. I find that hydraulic engineers say 6 inches in 24 hours is the maximum fall of rain that must be provided for in proportioning a waste weir. The signal service

officer at Altoona, so I have been informed, says, that during Thursday night, in about 10 hours, there was 5¼ inches fall, or nearly 12 inches in 24 hours.

Col. Unger says that a wooden bucket left out accidentally all night in front of his house, contained in the morning 8 inches of water. Now if this weir had been proportioned in accordance with hydraulic formulæ, which were based on previous known rainfalls, this waste weir would probably not have been too small for a rainfall of 6 inches in 24 hours. As the results show, it was too small for a rainfall of 8 inches in 10 hours.

In this connection I would state that in the *Engineering News*, I forget of what year, I found a description of a dam in California which drains a water-shed of 390 square miles. It was 110 feet high, 125 feet base and 15 feet width on top. The waste weir for this dam is 20 feet wide and 5 feet deep. If the water-shed of Conemaugh Lake was 50 square miles, and had a waste weir of the same size as that one in California, it would be proportionately 8 times larger. The actual proportions are for the California dam 100 sq. feet, for South Fork Lake nearly 500 sq. feet, or, in proportion to the water-shed, 40 times larger.

I think that if the waste weirs of most of the dams of to-day were calculated for a rainfall of 8 inches in 10 hours the majority of them would be found too small.

Another thing; the papers lay great stress on the fact that the pipes through the bottom dam were filled up. I have made no calculation myself, but Mr. Holbrook, Superintendent of the P. L. E. Railroad, informs me that he made a calculation of the amount of water these five pipes would carry off, and he found they would only have lowered the lake 1 inch an hour, so that with a rising of 10 inches an hour, that would not make much difference.

CHAS. DAVIS: I visited the dam on the 11th inst., seven days ago, and noticed about the same conditions as Mr. Roberts has described. I paid some attention to the crest of the dam and to the waste weir. I measured out from the right bank. The length of dam is 900 feet. Next to right bank, or next to weir, there is a stretch of dam still standing 300 feet long, then a space covered by the washout of about 400 feet in length, then a further stretch

of dam of 200 feet, connecting with the left bank. The breach extends to bottom of dam and is some 50 feet wide there. The dam is about 70 feet high.

I went down into the weir and took some measurements and levels. (I had a hand level with me.) I found the bottom of the weir somewhat irregular, and finally concluded to take a timber sill connected with trestle bridge as a base, as representing the crest of weir.

Standing on that I took a sight to what I thought at that time would represent the crest of the dam, *i.e*, a sight on the top surface of road on crest of dam at the breach.

I made the level of crest of dam 4½ feet above this sill. Before leaving waste way or weir I measured the width of opening under the bridge and found it to be about 105 feet; also measured it immediately below and found it 90 feet wide. I looked at the screen and made such measurements as I thought necessary.

I went into the weir also, to see if I could find any marks of the flood. At first I could not discover any. I thought I would see them on this timber trestle, but could not find them. Out in the weir itself I found marks on the shale banks and on the bushes, showing that the water was over 6 feet above the sill. It showed a 6 feet flow there instead of 4½ as mentioned in some of the newspapers.

Now, after going over on the crest of dam and examining the ground closely, I found I was mistaken in taking the sight for level of crest of dam above weir; that there was a sag in the crest in both banks contiguous to the breach, this sag extending back along road or crest some 25 or 30 feet; that the water in pouring through the breach had saturated the ground for some distance in from face of breach, and, of course, the crest had dropped down. Looking at the ground carefully, near the break, I saw numerous cracks. I found there was a sag of some 6 inches there. The crest of the dam was in reality 5 feet and over above the sill in weir, instead of 4½ feet. The top of dam next to weir was slightly elevated above other portions—say about 1 foot. This sill stands 8 inches above the floor of weir. On top of it is the screen, composed of vertical iron bars, ½-inch round, spaced 1⅜ inches

between centres and 18 inches high, connected by two horizontal bars $2\frac{1}{2}$ by $\frac{1}{2}$ inch. On top of that, for portion of length of screen, was a square piece of timber 8 inches square, with spikes driven in on the edges, making diagonals to the axis of the timber. These spikes projected out about 4 inches. This timber was probably a portion of boom which stood out in front of screen to keep the drift out of the weir. It was made to float, to rise and fall with the lake. The photograph of the weir as shown in the *Engineering News* is very good, but the obstructions are not as great as there represented. The point of view taken for picture tends to exaggerate the effect of the obstructions in the weir. The weir itself is at least 80 feet in length by 6 feet above the sill. This is the available cross-section. It is very different from anything I have noticed in the prints. It has been represented as much smaller. So far as the character of the work in the dam is concerned, it was much better than I expected to see. The dam was planned and executed by State engineers, and I think we should be very careful about criticising their work. (Mr. Davis then spoke of the puddle wall, describing it about the same as Mr. Roberts.)

Another point. In walking up the road to the dam, on the right bank of the stream, the bushes and tree-tops gave evidence by their inclination towards the dam, that when it gave away (half mile below being the narrows, and the stream making a sharp bend to the right) the water could not vent itself quick enough and had formed a whirlpool; the effect of this could be seen all along this road. The same thing took place at Johnstown when the stoppage occurred at the bridge.

After visiting the dam, as I could not get down again that night, I took the first train to the top of the mountains to Loretto. On my way I examined the Conemaugh very carefully, and found that there had been destructive washouts all along the line. Within 4 miles of the headwaters, at Lilly's Station, there had been 6 feet greater depth of water than had ever before been noted. The flood washed out the railroad here and submerged the coke ovens, or a portion of them at least. It was a very wild place all the way up and they had to run very carefully. At Loretto, the

gentleman with whom I stopped (Mr. Edward Glass), gave me his record of the rainfall, which was 5 inches in 24 hours. I saw the vessel in position in which he measured it, and do not think there can be any doubt about his measurement being correct.

I also took a Cambria county map found there, and calculated the water-shed of the South Fork valley above the dam, and roughly figured it at 60 square miles. I see it is given in this paper, *Engineering News*, as 55 square miles. The water-shed of the Conemaugh above South Fork Junction, I put at 70 square miles.

Mr. Davis then went on to give a description of the effect of the water from the dam down to Johnstown, which, not bearing on the question under discussion, is omitted here.

W. G. Wilkins: One or two more remarks I would like to make. In an article in the *Engineering News* a writer says that for forty years he kept a record of the number of dams that went out, and the proportion according to his record was one of earth, four of stone and ten or eleven, I have forgotten which, of timber crib dams.

T. P. Roberts: As Mr. McDowell is not here I will say that I had a conversation with him to-day. I asked him what his connection with this work was. He said he was merely invited to go up and see what could be done toward stopping a leak in the dam. They could not tell where the leak entered. He suggested that they get hay, manure and some brush with leaves on it and cover the slope as much as they could, on the place where they thought the leak might be, then dump clay on top of that, and that work closed the leak entirely. That was his sole connection with this dam, so far as I can understand.

There is one point I would like to call attention to. The average height of the flood-line to Johnstown is probably in the neighborhood of 30 feet. Of course there are some places above Johnstown where the water rose higher. Now, in watching the courses of flooded streams from the head waters, ordinarily the water begins to dwindle and lowers as it passes down the valleys, but in this case it seems to have maintained the same general height. I can account for it only in this way. Those streams were of unprecedented height. The Conemaugh was several feet

higher than ever before known, and the streams were over their banks in every direction. The valley was full from South Fork down to Johnstown. Now suppose that the velocity of this water was 9 miles per hour. When this current came out the velocity was something like 14 miles per hour, so that by gathering up water it kept its head. I do not know the exact time the waters struck Johnstown. I understand about 3.55 P.M. The time at South Fork was 3.08. But the time of the break of this dam no one seems to know exactly, although the consensus of opinions makes it just before 3 P.M. Now, from the time the water passed out of the dam until it reached Johnstown it had to pass over nearly 13 miles by the water-course. As soon as it reached the South Fork it ran up that stream and carried away the Pennsylvania Railroad bridge there, and here some of the water was temporarily stored. I can only account for the continued height that it was the waters already in the creek, caught up by the swift descent of the flood wave.

W. S. JARBOE: I heard of one clock in Kernsville which stopped at a quarter of four. Over in Johnstown, Walnut street, another stopped at six minutes of four, and I have seen several which all stopped at about six to eight minutes of four.

F. C. OSBORNE: Do you consider the workmanship good; that it was of first-class construction?

THOS. H. JOHNSON: In regard to the crest of the dam, I to-day saw a photograph of the dam, taken some time ago, from a point on the hill-side below, down stream, and at an elevation slightly above the crest of the dam, so that the crest was projected in a sharply defined line against the surface of the lake seen beyond it. The only evidence of a depression was a slight one near the centre of the dam, so slight as to be almost indiscernible in the photograph. Judging by comparison of the length of the depression to the length of the dam, I should say it was not over 150 feet long and exceedingly shallow, less than 1 foot.

T. P. ROBERTS: (Mr. Roberts here made a sketch of the section of the dam shown in the *Engineering News*, before referred to.)

The workmanship of what is left here is certainly excellent. I

do not know anything about the portion washed out. There is nothing remaining of it. You must recollect that this road here is of very compact material. There is no doubt that the dam was strong enough to resist any pressure up to its full height. The old part was certainly of excellent workmanship. It must be recollected that the old engineers of Pennsylvania had had a great deal of experience in the construction of these reservoirs. Mr. William E. Morris was the engineer in charge of its original construction. I have been looking up the records, but I think undoubtedly it was built on the plans of the other reservoirs. But it was never intended to overflow. It was much weakened by the reaction of the overfall which is always to be dreaded. We have on the dams on the Monongahela horizontal cuttings in the river bank where as much as twenty acres have washed out, caused by the reaction of the water.

W. G. WILKINS here read the article or that portion of it bearing on the question from the *Engineering News.*

In answer to a direct question as to what he considered the cause of the giving away of the dam,

T. P. ROBERTS said: No earthen dam ought to have water allowed to flow over it. The waste weir was not large enough to carry out the water. The exact dimensions and profile of it have not yet been fully determined.

ISAAC WINN: It seems to me there has been a great deal of distrust about this dam for years. Why did the people distrust it? They had had warnings repeatedly, but seem to have paid no attention to them. There evidently was something wrong besides this overflow. It is true the water ought not to have been allowed to overflow, for it took away the dam rapidly.

I think there has been great neglect on the part of some one. This dam has been in bad condition for years. From the information we can get, the repairing was not done as well as the old work. With regard to this wicker-work at the weir, we all know it would have been an obstruction to a great extent and would impede the flow of the water somewhat. I know in my experience in mill-races we always had trouble of this kind, and in the spring more than in the fall.

L. S. Clark: In regard to that boom I will say it was in the shape of a V and it was made to fall and rise with the lake, being fastened to the end timbers of the bridge. I think it was a good thing. I have been up there at all seasons and never saw brush or other obstructions in the net-work.

J. A. Brashear ended the discussion by summarizing as follows:

The general consensus of opinion is that for this kind of a dam this one is about as good as could be made, but a critical analysis of the discussion here to-night seems to point to one thing, which might have been discussed further, and that is, that some provision should have been made for just such a thing as happened and which destroyed the dam; that is, that it should have had a larger out-flow than was possible with the weir or shoot in use.

It seems to me to settle down to this, that the dam was constructed well enough, if there had been an out-flow large enough to take out the excess water. But there was not sufficient drain for the tremendous flow of water from this "cloudburst;" if there had been a means of opening that outlet so as not to have an overflow, it would have been the solution of the whole matter.

Society adjourned about 10.45 o'clock P.M. to September 17th inst.

S. M. Wickersham,
Secretary.

September 17th, 1889.

The Society met at their rooms at 8 o'clock, P.M.

Present: John A. Brashear, President; W. L. Scaife, Vice-President; T. P. Roberts, Charles Davis, M. J. Becker, Directors, and 17 members.

The President announced the subject to be considered was the appointment of a committee to meet a committee of the American Society of Civil Engineers to discuss the proposition co-relative to forming one great engineering society.

The President read the documents received.

MAX J. BECKER opened the discussion by saying: I can add but very little to the circular. The American Society of Civil Engineers, which I think is now about thirty years old, was at the time of its organization virtually a local society, because at that time there was very little engineering talent scattered throughout the country at large, and the membership was almost entirely confined to New York and its immediate vicinity.

But the Society has grown. I think that it now numbers something like 1200 members, and especially has its membership developed largely throughout the Western States and the interior of the country. There have been for some years past wishes expressed, especially by the western members, to have the Constitution and By-Laws of the American Society revised. Just in what way the reforms were to be brought about was not definitely expressed by anybody, but a general desire appears to be felt towards a revision, and at the last annual convention, which was held in the month of June, at Seabright, a motion was made to the effect that a committee of seven members be appointed by the President to undertake a complete revision of the Constitution and the By-Laws. The resolution passed without any dissenting voice.

It devolved upon me as President of the Society to appoint the committee, and I selected Mr. William P. Shinn, whom you all know, as chairman of the committee. He was, by the way, the mover of the resolution. I also appointed Major Michaelis, who was at one time stationed here in charge of the United States Arsenal, and now located at Augusta, Maine; Mr. Mendescohen, of Baltimore, is a member. Mr. Strobel, who was at one time a member of this Society, now located at Chicago, is another. Mr. Collingwood, of New York, connected with the construction of the Brooklyn bridge; also Mr. Brush, of New York, and Mr. Whinery, of Cincinnati.

The By-Laws of the Society require that any amendment to the Constitution must be voted for by letter ballot, and of course they have to be sent out in November in order to be voted on finally, or accepted or rejected by final action at the annual meeting, which is held in January in New York, and this circular was

written for the purpose of urging action on the points mentioned in advance of that time.

The committee has had one meeting in New York, but they soon found that their scope of duties was so extended that they could not hope to bring the matter so far forward as to have it voted upon or even send out the draft of the new Constitution and By-Laws in November, and they have come to the conclusion that they will simply report progress at the November meeting, and ask to be continued beyond the January meeting, having their time extended to the annual convention which is generally held in the month of June. So that the urgency is not so great as might appear from the tone of the letter, which was written, I think, before the committee held its first meeting.

The present Constitution and By-Laws are rather ancient documents. They have been patched and overhauled, altered and amended to such an extent that there is really no proper order or system remaining. They are not in good shape, chronologically or otherwise, and the desire for revision is general throughout the Society. I think this committee will not merely amend it, but will rather throw the old document into the waste basket bodily and make a new one, to be submitted to the members for their adoption or rejection, because the old one can not be patched up any longer.

Now, one of the points upon which a majority of the members agree is that they are anxious to increase their membership, and as a means of doing that they think that by organizing chapters or branch societies throughout the country, the membership can be largely increased and the general usefulness of the Society promoted. It is for that purpose particularly that this circular has been addressed. Just how that project can be carried out it is difficult to foresee. No doubt there will be much discussion, and the views of the members throughout the country are asked for. I think it must strike any one as a move in the right direction. The present membership of the American Society is of such a standard that the older members particularly would feel perhaps some reluctance in having it lowered. I think they would be in favor of having it maintained, but at the same time they feel that

they should not exclude any one who feels an interest in engineering matters and who ought to have an opportunity of participating in a discussion of engineering subjects.

In order to do that they will probably propose grades of associates or a junior class so as to give everybody an opportunity of coming in. Now if this can be done in such a way as to absorb the local societies which are now scattered throughout the country, which would not necessarily have to lose their identity, but would simply change into auxiliary or branch societies of the American Society, every man would become a member of some grade in the American Society instead of as now being a member of a local organization. It would bring the different local societies in harmony among themselves; they would all be simply chapters of the same mother institution, so that there would be a close relationship existing between them all.

This is the sum and substance of the subject that is proposed in this circular and address. The appointment of a committee, if the Society should see proper to entertain the proposition, should, I think, be accompanied by some sort of expression by the Society itself as to whether the measure is a desirable one, so that the American Society might know, in a measure at least, as to whether their project is viewed favorably or not, because it may have a bearing upon their own deliberations in the matter.

The benefits which the members of the local societies would derive would be the papers and publications of the American Society, the use of their library, a nice place to go to in New York, and a general exchange of fellowship and good feeling among the members of the profession.

THOMAS P. ROBERTS: I met one of our members on the street yesterday, and he told me that Mr. Metcalf was interested in this question. That was the first I had heard of it. I then, as the only member of the Programme Committee in the city, wrote a letter urging him to come, as we had been unable to get any papers.

A great deal can be said touching this proposed affiliation. While it is probable that our Society, at first glance, might regard the scheme favorably, it is yet a little peculiar from the fact that prob-

ably one-half the membership are not professional engineers. That point was partly covered by Mr. Becker when he spoke of having the local societies as chapters, independent within certain limits. In that way it is possible non-professionals might have the benefit of the publications of the united organizations without being compelled to pay the present large dues of the older Society.

We might lose our name and identity, but I presume, of course, we would retain our library, and conduct our meetings much as we have done in the past. All these matters would be very proper for a committee to investigate and report upon. I am in favor of a movement of this kind if it can be shown that it will lead to closer fellowship and promote the interests of the profession.

M. J. BECKER: I might add to what I have already said that the local Society of Cincinnati, and also the Society of Chicago, have addressed communications to the American Society of Civil Engineers, and expressed themselves very warmly in favor of some such movement. The Society of Cincinnati, consisting of the local members of the American Society, who have an organization of their own, have gone so far as to outline a certain way of bringing about this proposed arrangement; and while I do not fully recollect the details, I remember this much, that they would propose to divide the United States into districts. I think they suggested fifteen or eighteen districts. They would be outlined geographically, so as to remain adjacent and connected together, but the area would correspond to equal numbers of members in each district, so that the representations would be about equal. New York which, perhaps, would have three or four times the number of members within its own limits that there would be in any of the other districts, would simply represent three or four districts, whatever the number would be. Each one of the districts would be entitled to representation on the board. At present there are only five directors in the American Society, and, in order to transact their current business, three of them, under the Constitution, are compelled to be local members of the society, residing in New York. One of the two Vice-Presidents is, under the Constitution, compelled to reside in New York, and naturally the Secretary and Treasurer. Under these circumstances, some of the western people feel that

they have not a sufficient representation in the management of the affairs of the Society.

By the organization of these chapters, they think that proper representation and proper care of local interests will be obtained which they could not have under the present Constitution and By-Laws, so that the matter has been talked over and canvassed, I know, in Chicago, Cincinnati, Kansas City, and elsewhere.

Any committee that this Society might see proper to appoint for this purpose might be either instructed, or the wishes of the Society might be communicated to them, and they might be restrained in their actions and in their conferences with the American Society, so as to oblige them to report again, and, after the matter has been matured and about ready for consummation, it could be brought up here for our consideration before final action is taken.

J. W. LANGLEY: Some years ago there was an experiment tried in this country which has a little bearing on the present proposition. An attempt was made to start an American Society of Chemists, the headquarters of which were in New York. It grew out of the local society in New York. A proposition was made that all the chemists in the country should become members, and they were divided into two grades, those residing in New York or within fifty miles of it, and those outside of this limit.

The plan started off very well, but in a short time the membership fell off very rapidly, the outside members finding they were getting nothing for their subscription but the published minutes of the society, and they were only providing the means for promoting the interests of the New York members. While the society is still in existence, the membership has fallen off, and the society is not a national one in any sense.

On the other hand, at the recent meeting of the American Society for the Advancement of Science, held in Toronto, a resolution was introduced for the formation of another society. While no very definite action was taken at that time, I think it is quite probable that something will be done to form a National Society of Chemists. I am not in favor, however, of so merging this Engineering Society as to lose our individuality. We want to keep our own publications. If we should lose our individuality,

one of the principal motives for the continuance of the Society will be taken away, and we shall have no publications but those of the American Society. Would it not be possible to have an organization founded a little upon the plan of our nation; that is, that each society will keep its own individuality and its own publications if necessary, and be connected with a central society, very much as the States are, with a central representation at Washington?

R. N. CLARK: What Prof. Langley has stated recalls my experience with the Society of Mining Engineers, which has, for one of its principles, that it should never have any central body. In that it differs entirely from the Civil Engineers. In my western life we had there little bodies of our own, little meetings of our own, very much like our present meeting to-night. We had papers and discussions, and in that we carried out the idea of not centralizing ourselves too much and losing our individuality, which, I think, is the great point here. If we are to lose our individuality, being controlled by them, reading only such papers as are suggested by them, governed by their rules, I should object to it; but if we, outside of the general line of work suggested by them, can control our individuality and at the same time become a chapter, we will do a great deal better than if absorbed by them.

W. L. SCAIFE: It seems hard, at present, to come to any final conclusion in regard to this matter, and I think it would be well, at any rate, to appoint a committee to confer with the other committee and report to our Society. There appears to be a general consensus of opinion that the American Society ought to increase its usefulness in some way, and that if the different engineering bodies in the country could be united in some way, the engineering progress of this country would be greatly increased.

The members will probably recall the fact that some time ago we received a communication from the Kansas City Engineers' Club asking us to appoint a committee to confer with them in regard to some means by which members could be transferred from one society to another. They may remember, also, that a report on the subject was made and adopted by this Society. I merely mention this to show that there are other means besides consolidation by which the members of different societies in the country may

be brought into closer relationship. As the subject is one that cannot be settled by any one society or in one evening, I think the best plan would be to have our committee appointed to meet and co-operate with the committee of the American Society, and to report to our Society, for acceptance or rejection, the result of their conference.

The President asked Charles Davis for his views. He replied that he coincided with Mr. Scaife and Mr. Langley, and thought that the subject was an important one and that a conference should be held.

M. J. BECKER: I am afraid I failed to make this thing clear. I may have so expressed myself as to leave a doubt in the minds of the members as to what this thing means. What the committee of the American Society is trying to call out is an expression of the engineering fraternities of this country as to whether an affiliation of their members with the American Society was desirable. If they find the sentiment against it they will probably not incorporate anything of the sort in the new Constitution, but even if they do incorporate anything of that sort it does not follow that we are bound to be swallowed up by it. We can be just as independent as we are to-night. But it is simply courtesy in response to this invitation to let the American Society know whether we would favor anything of the kind or not. Now we can do nothing less than give them some sort of an answer. The only way to do is to find out among ourselves whether we want to join or not and let them know. That is all there is in it.

J. A. BRASHEAR: I think Prof. Langley expressed a very pretty idea if carried out. I do not see why it could not be, if the American Society would receive us in that way. Now if the American Society would say that for a certain sum any local society could be represented and they would be willing to receive the representation in their annual meetings, we would also get their publications. It does seem to me that something could be done in that way. We could have our own local society as we have it now. That might be suggested to the committee.

T. P. ROBERTS: I think the American Society should have outlined some policy or plan so we would have their idea, instead

of asking the local societies for their opinions. The first intimations should come from the party that proposes to wed. We are waiting to be asked.

W. L. SCAIFE: As I said before I do not think we can settle the matter here. As I understand Mr. Shinn's circular, he wishes not only an expression of opinion, but that a committee should be appointed by each society to meet a similar committee from the parent society and talk the matter over. For that reason I think we should only appoint a committee to-night, and, after their report, we can go over the subject again for final action.

MR. SCAIFE offered the following resolution, which was unanimously adopted:

Resolved, That the chair appoint a committee of three (3) to confer with the committee of the American Society of Civil Engineers, and report to this Society the result of the conference.

The chair appointed on the committee W. L. Scaife, J. W. Langley, and Thomas P. Roberts.

J. W. LANGLEY, after conclusion of the discussion, stated that he wanted to ask informally a question. He stated that the Crescent steel works are supplied with water from the Allegheny river by a crib in the centre of the stream. That in January last, when the water was high and muddy, they noticed that the water from their tanks which went into the boilers was very clear, and on examination it was found that it did not come from the river at all. It was highly saturated with bi-carbonate of lime and was very much harder than the river water. It appeared to come from springs in the river, and he wanted to know if such a state of affairs was known before.

T. P. ROBERTS replied that in pumping out water from a cofferdam at Lock No. 4, Monongahela river, a half acre was dredged out and water from several springs burst forth from the bottom which were perceptibly harder than the ordinary river water. It was perfectly transparent and seemed to carry traces of iron, rapidly oxidizing tin vessels. It was pleasant to drink and was very cold, about 56° Fahrenheit, if I remember rightly.

J. P. ROBERTS then went on to mention a theory advanced by

a gentleman some fifteen or twenty years ago for the improvement of western rivers by the use of submerged dams. He had noticed that there are a great many springs in the bottoms of rivers; that by excavating trenches, filling the same with some material impervious to water, selecting those places in the watercourses where these springs occur, the water would be kept at such a level that about 10 feet of navigation would be had all the year round. Unfortunately for this theory there are places where solid ledges of rock cross the water valleys, as at the Louisville Falls, and there is no apparent difference in the volume of water above the rock ledges and below.

R. N. CLARK: I would like to ask Prof. Langley if he knows of any analysis having been made of the waters of the Monongahela Water Company, which is obtained from submerged cribs.

J. W. LANGLEY: I have no information on the point.

J. A. BRASHEAR: I would like to ask if there has been any analyses made of the waters of the Allegheny and Monongahela rivers for the purpose of comparison. I have understood that there is much less lime deposit in the Monongahela than in the Allegheny.

T. P. ROBERTS: There is a difference in the analyses. Prof. Phillips has made a great many analyses of the water of both rivers. The Allegheny river water compares favorably with the best soft-water rivers in the West. The difference, however, between the two rivers, except in extremely low water, is very slight. There does not appear to be any permanent hardness in rivers that run a great distance. Antietam Creek, for instance, is very hard at its source, but at the mouth you can hardly distinguish it. The Allegheny river, I think, is almost perfectly soft water. There is certainly a greater percentage of mud in the Monongahela. In a very low stage, however, in the Monongahela the proportion of iron and sulphur water from coal mines is relatively so great that its waters below the mouth of the Youghiogheny become very perceptibly hard.

Mr. Roberts then went on to speak of a peculiarity of the Youghiogheny River, due to the fact that so much old mine water ran into it. Dams are sometimes constructed to hold back water

in abandoned diggings, and when these are let out all the fish for miles in the river are sometimes killed. The effect of sulphuric acid in the river is to combine with the free oxygen in its waters, which, after a certain limit is reached, asphyxiates the fish—and yet such fish found dead and floating belly up are gathered and eaten by the barbarian perpetrators of the outrage. However, the ordinary operations of coal-washing have doomed the Youghiogheny for fish. The advocates of the use of coagulents for clarifying water, at times have on this river a wholesale illustration of their plan. The waste from washers appears to turn the entire stream at McKeesport to a peculiar indigo-blue color, while, in recent years, it is observable, even at Lock No. 1, in the city, the bottom of the river can be discerned at a greater depth than formerly. It is also noticed that the iron-work about the gates corrodes more rapidly than it did in former years.

On one occasion I was standing on the Youghiogheny river bank, at a place three miles above McKeesport, and remarked that the river appeared to be very shallow, although I knew that steamboats went a short distance above this point. My reason for thinking it shallow was that I could see, as I supposed, the bottom plainly all the way across. A native of the place, in answer to a question, stated that the water was 16 feet deep. I could scarcely believe him, but just at the moment a tow-boat came along, and I knew the water was deep by her action.

What I took for brown-colored boulders in the stream was, in reality, flocculent, wavy masses of coagulated material, quiescent and suspended in the water a foot or more beneath the surface. The moment the boat had passed, I observed that the previously clear-looking stream had been churned up from shore to shore, presenting a brown and very turbid appearance. In the course of an hour or more the surface became clear again, exhibiting the same deceptive appearance. Ordinary sediment in our waters, without the aid of a coagulent, I am positive, would never have settled or acted as this water did. It is quite possible that there are periods during which the Youghiogheny river at McKeesport is unfit as a source of water-supply. I believe there is, as yet, no general complaint in regard to the water, though individ-

uals have stated to me that they thought it was occasionally very hard, but, being clear, others thought it was simply perfect. Clear water poisons vastly more people in this country than are killed with mud.

Adjourned at 9.30 o'clock.

S. M. WICKERSHAM,
Secretary.

OCTOBER 15TH, 1889.

SOCIETY met at their rooms at 8 o'clock P.M.

Present, President, J. A. Brashear; Vice-Presidents, W. L. Scaife, A. E. Hunt; Director, C. Davis and 52 members and visitors.

The minutes of September meeting were read and approved. The death of W. R. Jones was announced and, on motion, a committee, composed of Wm. Metcalf, A. E. Hunt and A. E. Frost was appointed to properly prepare an expression of the feelings of the Society on the occasion and report the same.

James O. Handy was duly elected a member.

Mr. Isaac S. McGiehan was introduced, and made the following statement on the subject of

STANDARD METAL TIE.

GENTLEMEN: I can assure you that I felt not only flattered but pleased to receive the invitation of your Vice-President to say a few words before such an assemblage of learned gentlemen, and it is not without some fear and hesitation that I shall proceed to say anything on the subject of metal ties. I am aware that there are times when it is comparatively easy to make an acceptable speech or address, and especially when the learning of the speaker and his command of language is not below the intelligence and comprehension of his audience. One can often blend words together and create sayings mirthful, witty or sarcastic, as the occasion may require; but when you stand up to discuss or treat upon an engineering problem before a body of engineers, I can assure you it is far more difficult.

Experience has taught me that on such occasions it is best to

rob the subject of its frills and feathers and get right down to hard meat and solid facts. I do not suppose that you gentlemen would care to have me read the statistics which I have gathered on the question of metal ties. You would not care to have me absorb so much of your valuable time, because it would take considerable, so I will just give you a few ideas on the subject as I have gathered them for myself.

I find that the first metal ties were used, as far back as 1860, on the Paris, Lyons and Mediterranean railway. Since that time they have been creeping in very gradually all over the European countries, until now, I may say in the words of Colonel Mulberry Sellers, there are millions in use. On the India Railway line there are over 1000 miles of track now laid on metal sleepers, and they have been adding to these constantly. I do not believe, however, so far as I can tell, that the tie which they have adopted is a perfect one, and yet the India railway runs the fastest and heaviest trains in India, and their immunity from accidents has become almost proverbial throughout the world.

At the International Railway Congress in Paris, which was held recently, a series of questions were prepared and sent to all the leading railway engineers throughout Europe, asking that they report upon the experience they had had with metal ties, and a great many of them rendered favorable reports. I may say all the reports that were rendered were favorable.

Among the reports rendered was one by Mr. Mayer, who was Chief Engineer of the Simplon railway of Switzerland. He reported that they had had them in use since 1863, and that up to the present time he had been gradually inserting them, until now he had 129,990 ties in use. The tie which he has adopted weighs 99 pounds and a fraction. It is made of homogeneous iron or soft steel with a resistance to a breaking strain of 60,000 pounds per square inch. He reports that they have adopted them as a standard, that the matter is no longer one of experiment, and that he is inserting from 15 to 19 miles annually.

What makes these statistics as coming from Mr. Mayer interesting, is the fact that the road is notorious for its steep grades and short curves. He gives the grades to be 121 feet per mile.

That is very great. He also gives the curvatures as 1100 feet. He says that he runs from 28 to 30 trains daily in each direction. That the speed on branches is in the neighborhood of 28 miles per hour. On the main line he runs 40 miles per hour. He gives the weight of his locomotives at, I think, 34 tons, or in the neighborhood of 6½ tons per wheel. These figures are taken from a few translations which I have here. I am sorry I have not this paper. He states that his rails are 65 pounds, 19 feet long. Since 1884, however, they have been making the rails 39 feet long, putting in 13 ties to each rail.

I find also, that in England, France, Germany, Holland, Belgium, Austria, Russia, Switzerland, Italy, Spain, Argentine Republic, Sweden, Denmark, Cape Colony, Egypt, Algeria, India, Japan, Queensland, New South Wales, Chili and Mexico, some of the leading railroads have adopted metal ties, so that there is no question, seemingly, of their success.

Another one of the engineers who reported at the meeting says that on a section of 12 miles the third year he had the ties down, his expense for maintenance was $869, against $1563 for the same section with wood ties during the same period at another time. Mr. Mayer also reports that with the amount of ties he had down, 129,990 in all, in the five years only 48 ties were removed because of breakage, while with the wooden ties on the same section and same number of years from 20,000 to 25,000 ties would have been removed and replaced with new ones, which certainly shows in favor of the metal tie.

The pattern used by Mr. Mayer is what is termed the "Helfe" system, which is very similar to the Post tie represented in the *Engineering and Mining Journal* for December 29th, except that he used a clamp and wedge instead of bolts, which the other system has.

I find out of 84 reports which came into the Paris Congress there was not one man out of the whole lot who had not tried or used metal ties, and endorsed them. The showing which you get from this would seem very much to favor the metal tie, and their adoption shows that they are more economic, safer; that they do not wear out so quick, cost less to maintain, and in a great many

ways they are advantageous, and if you consider the climatic conditions of the countries where these ties were used, which were certainly adverse to them, it seems to me their adoption here would be far more beneficial than there.

Another advantage which I would mention here with reference to the metal tie is the fact that in case of floods and washouts, the ties and road remain in pretty good condition and can be used afterwards without any degree of risk whatever, while with the wood tie they invariably float up, disorganize the road-bed, become out of line, and, as a rule, the road-bed has to be re-made, the ties re-tamped, and the rails re-laid, which is, of course, expensive and annoying.

I have gone well over the subject, conversed with a great many engineers, both foreign and American, and notwithstanding the great advantages shown, and the large numbers of them in use at present, I do not believe that they have yet got a tie which is perfect on the other side. I believe that the problem of a perfect metal tie remains yet to be solved by American engineers, and I believe that, with the help of Pittsburg and some of our friends, we can do it. The first form of tie, I may say, that was ever used was of a longitudinal character; that is, it ran along under the rail. The next form that was used was termed the "bowl" sleeper, which was like an inverted bowl, one under each rail, with a tie-rod in between each pair. At that time they did not use metal cross-ties, the engineers considering it unsafe from the fact that they were made of cast-iron, and they invariably broke in the centre, over the solid portion of the road-bed.

On the India State railway the first difficulty they found with the metal ties was their getting out of line. They would tilt down on one side and then on the other, and slide sideways. The first experiment they made was to use an inverted section with the ends bent down to prevent it from going sideways, but when the train would strike a curve, and exert its force on the outer rail, the ties under that rail would sink and the end on the other side would lift from its anchorage which it was intended to take, and consequently it would slide and they could not prevent it.

The next experiment they tried was to dig a trench in the

neighborhood of 1 foot or 18 inches wide right along in the centre of the road-bed between the ties, and remove that portion of the road-bed. The effect was that it worked admirably. The ties would remain in line perfectly. The foundation seemed to be perfect under each rail, so that the centre would not receive the force and swing of the train, and which was reduced to some extent. There was no breakage reported after that trench was dug and the maintenance was reduced by the plan.

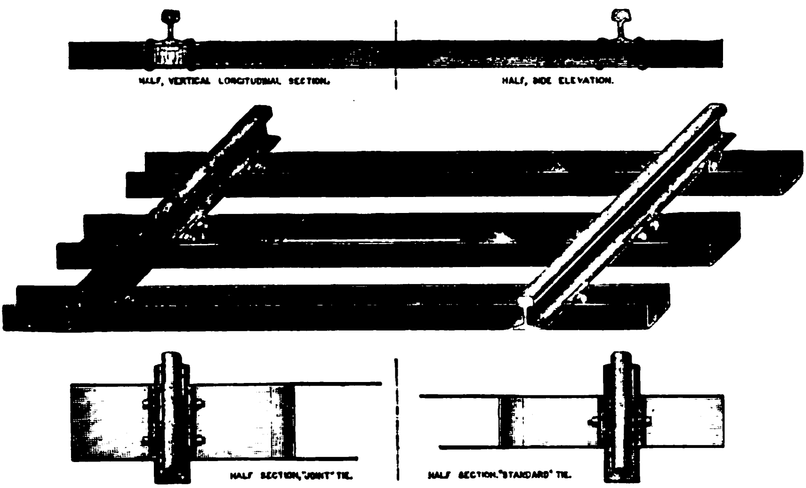
The only remaining defect of those ties was the effect of the metal contact between the tie and the rail, and it was impossible with that metal contact existing to make the fastenings rigid, so that all the parts became loose and they would rattle, making it both annoying and dangerous. And up to this time they have not found a method to destroy the metal contact or provide a fastening which was sufficient to hold the rails rigidly to the tie.

The metal ties which we have tried heretofore have been either importations from the other side, or imitations of some of their designs, and we have had precisely the same trouble that they have had. They will not stay in line, they are hard to tamp, and the fastenings are apt to get loose; also, the metal contact is bad. On the Pennsylvania railroad some experiments were made with the Webb pattern, which is an inverted section, with the sides slightly flaring; the rail clamps are riveted fast to the back and a wooden wedge on the ore side to hold the rails. You could not keep them in line. They were very crooked, indeed. One day while I was looking at these ties there was an old Irishman standing alongside of me with a very disgusted look on his face, and I asked him what he thought of it. "Well, sir," said he, "since you have asked me I will tell you. It just looks like the front rank of Casey's brigade; one end's out and t'other is in and, be jabers, it's crooked from ind to ind."

The cost of the Webb tie in the United States would be rather prohibitory to its adoption, because it is very heavy. They have never been made of the light section, except for experimental purposes, and then it bent. I believe that for a metal tie to be acceptable in the United States, where wood is seemingly so plenty, it must possess some practical features. I believe that the centre of

the tie must either be removed, as in ours, or otherwise the centre should be arched, so that the tie spans that solid portion of the road-bed, and so that the foundation is directly under the rail, and not in the centre; I believe it should be a tie that could be easily tamped, and then, I think, the fastenings should be near where the metal contact is broken, and where the tie and the rail are held rigidly together, with no possibility of loosening or the parts becoming disorganized.

Then another feature, which is not the least one of the lot, a



The Standard Metal Tie.

metal tie to be acceptable here must be cheap. We cannot make a metal tie for our use the same as in foreign countries, regardless of cost, because we have a supply of wood which they have not. The principal features are those of safety, speed and durability there, to which, for our use, we must add cheapness. Of course, the paramount cost of any metal tie you would put down is bound to be more than that of wood, at the present price of metal. If we consider cost only, however, we would never make any progress. We have gone on building large coaches, heavy locomotives, and running faster trains than we ever did before, and yet we have

made no improvements whatever for those engines and cars to run on, or paid any consideration to the road-bed, except that we lay a heavier rail. The wood ties are not even so heavy as they used to be, and not so long.

The reduction of the difference in cost, I should add, with the press here, thanks to one of your members, Mr. Aiken, who designed it, is such that we can now produce a tie which is within the means of all railroad people. The difference in cost between this metal tie and the present wood tie is just the difference between the cost of stone and gravel ballast, so that if the railroads can afford to put down stone ballast and try to preserve the ties, they can spend the same money and put down the steel ties, and they would not need the stone.

The tie which you have seen here is worthy of my explaining a few of its features. The central portion is cut out to prevent the tie from slipping, and in the centre the resisting plates are turned up, so as to stand as nearly as possible against the central line of solidity in a transverse direction, and consequently they take resistance against the solid portion of the road-bed, and the tie will stand in line perfectly. Then the fastening is made with these two clips that hook to the bottom of the tie and slide over the rail-base.

The wood, which first is treated so as to render it indestructible, is held in place by the clip at the bottom, and on the top by the rail, and can never get out or become loose. If there should be wear on it, there is room left on the side to take it up, but I hardly believe there will be wear, for if it shrinks side-ways the clip will follow it up, and it will never shrink end-ways. We made some tests to ascertain its resistance. On the Pennsylvania railroad they put 101 tons on top of it, which was all the press would stand, and could not fracture the block. We put 27 tons on a tie supposed to support the same weight, and it was sufficient to destroy it. I believe with that fastening, and with the bolt that goes through here to hold it together, we can get a pressure to hold the rail down on top of the block anywhere from 5 to 10 tons, so that when your rails are all in line the ties and rails form a structure, and one supports the other. I think we get a uniform elasticity,

because when any portion of the structure sinks it carries its neighbor with it, as they are all joined together. The wood acts as a cushion, the rails do not touch the tie, and there is no metal contact, and I cannot see where there will be any objection.

Then it is proposed to dispense with the use of fish-plates. As you all know, the fish-plates are so placed as to take the weight of its load off the rail. Its opposition to the weight is at an angle, it being placed under its head, and then it takes its support from the base of the rail, being squeezed in between the two. Of course, the bolt-holes in the rail are larger than is necessary for the bolts to pass through, in order to compensate for the contraction and expansion of the rails, so that the only support the fish-plate has is simply its close fit in that small space between the head and base of the rail. Consequently, when a wheel goes over it there is an instantaneous movement from the end of one rail to the end of the other. This may be incorrect to some extent, and yet you may say it is almost instantaneous, because you cannot tell when it leaves one until it touches the other, so that at one moment you will have a pressure on the one rail corresponding to the weight of the wheel and its load, and immediately it is transferred to the other, so that as one rail goes down the other comes up, and it is a tremendous reciprocating strain which has a tendency to break the fish-plates. I have counted in one section of road, from Menlo Park to Metuchen, 74 fish-plates on the main line that were broken. That is only about 2½ miles. I afterwards talked with the engineer of the road, who told me that it was impossible to make and put down fish-plates fast enough. The surface which the fish-plates have opposed to the load is, I think, 24½ square inches under the head of the rail, while with this tie, from its side to the end of the rail, we get a surface of 29½ inches, directly opposed to the load; then the clamp comes over the top of it, holding it down.

When you take into consideration the weight of our locomotives and trains, and the speed at which they travel, and especially if you have read in the papers of the recent accidents, like that occurring on the Pennsylvania railway at Rahway, by the spreading of a rail, causing the whole train to go over, I think you will agree with me that it is really dangerous to continue the use of wood

ties and imperfect spike fastenings, while we are still increasing the speed of the trains. I think you will agree with me that it is time for the railroads to take up the metal tie, or something which will add to the better service of our rails. I presume metal is the coming thing for it. I do not know of anything else.

Now, I have already taken up a great deal of your time; more than I intended to. In fact, I did not intend to say half as much as I did, and I ought to apologize for keeping you, but I want to say before stopping that I have been more than pleased to meet an audience of gentlemen like this; and with all the gentlemen I have met in Pittsburg. I find that a great many of our best firms come from New York to Pittsburg to get not only engineering ability, but to promote their schemes, which are only, you might say, in a primitive way contrived in New York.

And now, if you will pardon me, I will close something after the manner in which a friend of mine said of Mr. Oliver Ditson. He dressed in a clerical fashion, and while visiting some friends he was called upon to say grace. He complied. He got up and said a great many things, but during his saying of them he forgot to say "Amen." He could not think of the word to save his neck. He tried every way; he got embarrassed, and finally, in desperation, he said: "Yours Truly, Oliver Ditson," and sat down.

Discussion of Isaac S. McGiehan's Remarks.

A. E. Hunt: Mr. McGiehan has undoubtedly paid a great deal of attention to this, but I would like to ask this question: What do you consider the essential points of difference between the metal and wooden ties which causes this extra amount of creeping in the metal ties, and what precautions are you now taking to avoid it more than what you have stated, to correct the differences between the metal and the wooden ties? The metal tie is smoother; there is less friction.

I. S. McGiehan: From the fact that the wooden tie is soft on its outer surface, and that stones and other articles stick to it, it becomes so rough that it cannot slide. On the metal tie the surface is smooth, and we must devise some artificial means to pre-

vent the creeping. All of the devices created heretofore to prevent them from creeping or going side-ways have been to spoon the ends down; then they found they would tip down on one side. The road-bed is always soft at the outside; at least as the railway people tell us they are constantly tamping at the outside. it must be the softest at that point and more solid in the centre. If it is more solid in the centre the metal tie will break there more easily. The more it tips the more strain it receives, and consequently slides more.

If you get a ball started it will run down hill very fast. If you prevent it from starting it will stay where it is. The idea is that the wood tie does not start to slide, while the metal tie will slide excessively if it starts at all. To prevent that you must remove, in some way, the central portion, which is more solid than the outside portion. The rise and fall of the ends may not always be so perceptible to the eye. But I have laid on my stomach on the side of the track and watched the ties move, and I never once found that both ties sunk alike; one side would sink more than another, and it would be found that there was a round portion to the road-bed on which these ties rested. If you can get a perfect line under each rail nothing will disturb it, because you understand that it is the oscillating force of the train which creates the disturbance in the track. At curves it is greater than on the straight track. Railroad men will say they get no such force on a straight track, but they do.

H. D. HIBBARD: What kind of wood is used?

I. S. McGIEHAN: It is an oak block.

H. D. HIBBARD: How are they preserved?

I. S. McGIEHAN: Those we have been using are dipped in creosote oil, but it is intended hereafter to put them in a vat containing oil and force the oil in with pressure, so that every particle and crevice will be filled with the oil. I do not think it will decay. In the matter of cost these will be very cheap. We can supply them at two and a quarter cents each, and you see from the construction of the tie how easily they can be replaced.

H. D. HIBBARD: How do you prevent the tie from rusting in contact with the wet ground?

I. S. McGIEHAN: At present we paint with tar.

EMIL SWENSSON: What will prevent water from standing in the tie?

I. S. McGIEHAN: There are four holes in the bottom of the tie which will enable the water to run right out. In the winter-time the water will freeze, and will thereby add to its weight and become very solid; in summer-time the water will sink into the ground.

H. D. HIBBARD: It seems to me that the question of cost, which has not been given a great deal of attention, will have a great deal to do with the introduction of this tie. I presume it costs not less than five times as much as the wooden tie. I understand that in Europe wood is scarce and used for very few purposes; but this objection does not apply here, and the cost will prevent the metal tie being used. It is a question to me whether the conditions in this country have yet reached the point where metal ties are to be introduced. I would like to ask if any have been sold yet.

I. S. McGIEHAN: I will say, in answer to that, that we have several orders which we have been unable to fill for the simple reason that we saw it was necessary to make the tie at the lowest possible cost for the railroad people. With the assistance of Mr. Aikin, who designed our press, we got up a very nice machine. It makes them very rapidly, and the cost of labor is reduced to very little, and will still go lower. In comparison with wooden ties, you will probably be astonished that it is only 29½ per cent. more per mile of track than the cost of the common wood tie of to-day.

H. D. HIBBARD: Do you mean that you can furnish these at $2.25 each? How do you make, then, with wooden ties at about 84 cents, the cost of steel but 29 per cent. more?

I. S. McGIEHAN: We do not put in so many. In the next place there are no spikes and no fish-plates. As to the cost of wood ties, the Pennsylvania railroad paid, for first-class ties, 70 cents in 1884, and are paying at least 20 per cent more now.

H. D. HIBBARD: Is not that delivered?

I. S. McGIEHAN: No, sir; that is f. o. b. I took the cost from their books. I do not mean saplings, but ties such as the

Pennsylvania would use. Then you must consider the wear. The average life of a wooden tie is in the neighborhood of five years, while the average life of this tie will probably be forty; so that you see the first cost, while more expensive, than wood, will, in the long run, be much cheaper. The Pennsylvania railroad tried metal ties at one time, but because they went sideways they threw them out.

MEMBER: What is the weight of this tie?

I. S. McGIEHAN: This tie will weigh, I think, in the neighborhood of 69 or 70 pounds.

MR. DAVISON: I have been surprised at the figures you give for the cost of the tie. It is higher than some experience I have had, but you will probably be able to regulate that matter. I think you have failed to mention, in explaining the resistance of wooden ties to the lateral motion, that it is very largely due to the fact that probably 50 per cent. of the wooden ties are not straight. They are crooked, and have projections which add, I think, very largely to the resistance to the lateral motion.

I. S. McGIEHAN: From first observation that would seem very true, and it is no doubt correct to a great extent. But I have seen miles of road built with ties that were sawed positively square and yet they did not slide sideways.

A. E. HUNT: I believe in what you say that the metal tie is the tie of the future, and it seems to me that a step is made in the right direction here in reversing the channel or sleeper itself. I think you are on the right track; at the same time it does not seem to me that you have quite answered the point which I asked about first, as to what was the difference, and how do you correct these differences, between the wooden and metal ties. The thought occurred to me that you could make a comparison, ascertain where the wooden tie has advantages over the metal, and then try to correct those disadvantages in the metal tie; that, perhaps, would give you an idea on which you could work. It seems to me that the wooden tie is solid in the centre. You failed to show why the rigid metal tie should be cut out in the centre. It seems to me that is not the objection. Would it not be possible to put their weight or greater weight at the ends of the metal tie, or

put on projections to prevent them from creeping? Perhaps these would have the same effect as extraneous substances on the timber tie.

I. S. McGIEHAN: I think, in the body of my address, I described the way they do on the India railway, where they had trouble in the tie sliding side-ways. When they dug the trench in the centre this was prevented, since they removed the central foundations so that the weight of the rail rests on an independent foundation on each side of the centre. We do not propose to dig a trench, but we take out the centre of the tie, which we think, is practically the same thing. Another thing I want to call your attention to, is that some of the ties used on the other side are in connection with the English bull-head rail, and you have none of the broad flange which we have here. They must line up their track after the rails are in position, while here the track is comparatively straight at first.

W. THAW: What road was that of Mr. Mayer in Switzerland?

I. S. McGIEHAN: The Simplon railway, I believe they call it. I got the translation from the *Revue Industrielle*, which was received the day I left New York.

H. D. HIBBARD: What material is this tie made of?

I. S. McGIEHAN: Soft steel.

MR. VERNER: I suppose that trains will get off the track even with this tie, and one serious objection to that tie would be the trouble of replacing it in getting the ballast from the tie. It would hardly be enough of a cushion, as the wooden tie forms in such cases. How will you get over that objection?

I. S. McGIEHAN: The train will, of course, cut into the tie, but ordinarily there will not be sufficient damage but what the tie can be easily repaired and replaced in the track.

The Society then took a recess to examine the sample tie shown by Mr. McGiehan.

After which the Society adjourned at 10 P.M.

S. M. WICKERSHAM,
Secretary.

NOVEMBER 19TH, 1889.

SOCIETY met at the rooms at 8 o'clock P.M.

Present, President J. A. Brashear, Vice-President W. L. Scaife; Directors Chas. Davis and T. P. Roberts, and 20 members and visitors.

The following-named persons were balloted for and elected members of this Society, viz: W. A. Cornelius, Hazelwood, Pittsburg, Pa.; W. G. Bell, Brick Manufacturer, P. O. Box 976; J. J. E. Wolffe, Keystone Bridge Works; C. H. William Ruhe, 102 Bluff Street.

The President appointed the following Committee on Nomination to report candidates for the various offices to be filled at the January meeting: Wm. Thaw, Jr., *Chairman;* H. D. Hibbard and F. C. Phillips.

After which Arthur Kirk read a paper on the "Use of Dynamite in Breaking Up the Jam at Johnstown," viz.:

REMOVING THE DRIFT JAM AT JOHNSTOWN, PA.

PITTSBURG, PA., November 19, 1889.

TO THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

Gentlemen: When I arrived at Johnstown, Pa., about noon, June 1, 1889, it presented one of the most appalling and unprecedented scenes the eye of man has ever looked upon. The great outpouring of water from the precipitous mountain sides of Somerset county had filled the beds of all streams to overflowing height never before seen in that region, and as it had been customary for years for every one who wished to encroach on the bed of the streams, the Conemaugh had been so contracted that just at the lower end of Johnstown there was not space for this great quantity of water to pass, and a great portion of Johnstown was flooded to from 5 to 10 feet deep; for instance, one man, called McConnaughy, had stealthily encroached on the bed of the Conemaugh until he had sixteen tenement houses standing on ground properly belonging to the bed of the river. These sixteen houses were among the first to go, and formed the nucleus of the jam against the stone bridge at the lower edge of Johnstown. And

I may here remark, there seems to have been Divine retribution in the fact that Mr. McConnaughy was lost with his sixteen houses, and his body never found.

This was the condition when the great avalanche of water, 30 to 40 feet high and 500 feet wide (from the broken South Fork dam some 11 miles distant), rolled across the business portion of Johnstown, bearing on its crest every floatable thing that it had gathered from the 11 miles of narrow river bottom it had travelled, and much unfloatable matter under ordinary circumstances was swept along at a furious rate as if it had been feathers; for instance, a car loaded with pig-iron which with its load must have weighed not less than 60 tons, had been borne along not less than a quarter of a mile when it struck, and in one moment demolished, two fine 13-inch wall brick-houses (built together), and swept its Mansard roof away in a moment across the sites of less substantial houses that had gone before it with the wave. These were all hurled with tremendous force against a steep hillside, and houses, furniture, feather-beds and grindstones, pianos, stables, heavy railroad iron bridges and railroad tracks all broken and mixed up, with (estimated) from 3000 to 5000 human beings, of all ages and sexes, struggling in the seething mass. The wave thus loaded dashed so furiously against the mountain side that it recoiled and dashed against the Pennsylvania railroad stone bridge, about one-third of a mile below, consisting of 7 spans, of about 75 feet each, of massive masonry. This acted like a huge strainer, letting the water pour through it, but arresting railroad cars, loaded or empty, huge trees, some of them (estimated) 5 feet across the stump and 80 to 100 feet long, with roots and branches all attached. This soon collected débris and formed a solid dam across the whole 7 spans of the Pennsylvania Railroad stone bridge, and the water for a short time rushed 2 or 3 feet deep across the top of the stone bridge. Here was formed what is known as the Johnstown Drift, the like of which was never seen in the world. The heavy articles soon sank, taking with them the lighter, and the water, checked in its mad career, stopped and deposited its burden of thousands of tons of sharp sand and plaster, gravel, etc., to fill up the intricacies and solidify the mass, which I afterwards measured and

found to be 350 feet wide, 800 feet long up stream from the Pennsylvania railroad bridge, and apparently of an average depth of 20 feet. Many places near the middle of the stream must have been near 40 feet deep, and before I describe its removal I should mention that the whole mass near the stone bridge appeared to be interwoven with hundreds of miles of telegraph wire, telephone and heavy electric copper wire, all of which gave us much trouble from its being rolled up and interwoven in every conceivable manner; all through the mass another great cause of trouble was fine roots of trees interwoven in the mass of débris. I never before had any idea of the length and strength of tree roots. Permit me here to remind you that the whole 11 miles the South Fork wave had traversed before it came to Johnstown lay along a mountain gap and was an almost unbroken forest of healthy growing trees, whose branches often met across streams, and thick mats of laurel, and every tree and shrub known to such places, with scarcely one acre of cleared cultivated land on the whole 11 miles. The wave traversed all this mass of forest growth, suddenly tore out root and branch, earth and all, by the acre, as if they had been stubble, and their roots, being washed and cleaned of bark and earth, had become entwisted and entangled around among logs, demolished houses, etc. This also added to the difficulty of removing the drift, for we would find what appeared to be the top of a small sapling just sticking up near enough to the surface of the water to stop the floating drift and give trouble; then two or three men would take hold of it and pull at it, but all to no good; then as many as could would take hold of it, still no good. We one day connected a full sized Pennsylvania railroad locomotive to one of this description, working a 2½ inch cable over a snatch block, and the locomotive pulled and pulled at it until it pulled some 30 feet of tall young birch or willow tree (we could not tell which, for every particle of bark had been ground off it), then came its multitude of small roots, all entangled in a large mattress of telegraph wire, and after spending more than an hour with a locomotive and 10 men of a wrecking crew, and drawing a 2½ inch cable to almost its snapping point, we were forced to lower it down and leave it in the water, for we had no way of getting at it to chop off the roots,

and it was hugging the stone bridge so close we durst not dynamite it for fear of injuring the bridge. I may here remark, that I was forced to take great notice of these tree roots as they had been torn out and washed clean in many instances without being broken, until they branched off and off, still becoming smaller, often not thicker than a knitting needle, and I am much inclined to believe that the length of tree roots approximate the height of the tree while growing.

STRENGTH OF TREE ROOTS

of the willow and birch families appeared to be of the same textile strength as iron rods of the same diameter.

THE HUNTING FOR VALUABLES

by my men was another source of great trouble. I kept a crew of from eight to twelve men constantly employed making charges or carrying down and placing them in position, arranging wire, etc., and, although I allowed them one dollar per day more than was customary for other work, yet a week or ten days was as long as I could keep a man; then I would have to take on a new hand and teach him again. My work naturally took them much over the drift, and they would sojer off and hunt for valuables whenever an opportunity presented itself, and whenever they could get their pay they must go home, and would be seen going to take a train with a mule-pack load of valuables they had found among the drift.

REASONS WHY ALL THESE DIFFICULTIES ARE MENTIONED.

I have thus been led to enumerate some of the difficulties in the way of removing the drift at Johnstown, because I have found a great many men who never were at Johnstown, and never saw anything approach it, and yet really thought they could have removed it in one-fourth the time it took, and done it better. I think they were honestly led to think thus because they did not know the great difficulties we had to contend against. I think my description of a portion of the difficulties must convince you all that no such combination ever existed in the world before; and this remark will apply to everything else connected with the Johns-

town flood. For instance, as soon as I had made an observation, and decided on a plan, I went to find General Hastings, who was said to have full charge of all matters. I found him in his headquarters, just established in the railroad tower, standing on its steps surrounded by at least twenty men all eager to lay their cases before him; mostly men like Mr. Eisenberg, from Williamsburg, who had spent one day and two nights guiding five wagon-loads of provisions over the mountain from Williamsburg, and all anxious to have General Hastings order what to do. Some of these men had been hunting General Hastings for hours, and, of course, were out of humor; but General Hastings' calm, cool manner, with soothing voice, and his quick dispatch of business, soon allayed all bad humor and did great and invaluable services there. This necessary chaotic state gave great trouble.

Beginning Operations with Dynamite.

The large drift-raft I have already in a brief way described, had contained hundreds of wooden dwelling-houses, and much light burnable material, which had caught fire on Friday evening and had burned down to water surface, for, although the water at first ran over the stone bridge, yet it soon scoured out a channel through the shale rock in the bottom of the river, and was, by this time, rushing out under the drift and had left the drift a compact dam, as I said before, 350 feet wide across stream, and 800 feet up stream from the stone bridge, ranging in thickness from 20 to 40 feet, which had by this time been all burned over down to what had been water-level before; the water cut its way through under the mass, and

How to Remove what was Left

was the question to be solved. After carefully surveying the situation, I applied to Mr. Plum, Assistant Superintendent of the Pennsylvania railroad, for authority to act. He referred me to General Hastings, who, after talking the matter over, said it was very important to have the drift removed for several reasons; among other reasons, to get the thousands of dead bodies out that were supposed to be in the drift and keep them from contaminating

the water in the stream. He at once gave me full authority to do anything I could to clear the stream, but could give no tools of any description to work with, and as all the hardware stores in Johnstown had been swept away none could be bought there. I at once telegraphed to my office in Pittsburg for an assistant, a blasting outfit, and 100 pounds of dynamite; but how to get the dynamite to Johnstown was a question, for orders had been given to receive no freight for Johnstown. Application was made to Robert Pitcairn, Superintendent of the Pennsylvania railroad, who at once gave an open order for all I wanted for removing the drift at Johnstown should have best dispatch by first train, and my assistant and supplies were at Johnstown by daylight next morning; and I should here thank Mr. Robert Pitcairn, that all the time I worked on the drift all the dynamite and supplies I needed came through with the utmost dispatch, without any charges, which gave me great assistance and encouragement. I at once commenced to use dynamite in blasting near the stone bridge, as this was the lowest end of the drift, and the water was by this time running out very strong from under the drift, and I saw it would easily carry away any floatable material I could liberate. As I had to commence blasting close to the stone piers, I at first used charges of 5 pounds each; these I found I could use, and this amount within a few feet of the stone-work and do no harm. Then, as opportunity offered, I increased the charges to 10 pounds of dynamite, and fired 3 to 6 shots simultaneously by using an electric apparatus and exploding fuse in each bundle. I often had nails driven half through a piece of flooring board to keep the cartridges from slipping off the board, and had four cartridges tied on each side of the board by twine at each end of cartridge, then four more on each side, then four more, making a torpedo of 24 cartridges, or 12 pounds, tied on to a piece of flooring board with two electric exploders, one in each end of the charge; then, by pushing the charge or torpedo down between the logs I could sometimes get it 6 to 10 feet under water; then by placing a line of 6 to 8 of these within co-operating distance, say 10 to 20 feet apart, and firing all simultaneously by means of a battery, each torpedo, if placed close to a large strong log, would cut it off in sections, and it, with its superin-

cumbent weight, would be hurled in the air often 50 feet, and the lighter articles often 100 feet. A column of water often 20 by 100 feet would be thrown 100 feet in the air and fall back in heavy rain; this had the effect of shaking all loose. Of course, the heavy articles returned earthward first and sank; the lighter articles would float off down stream.

Of Making a Sausage Torpedo.

Again, I had water-tight gum tubing 2-inch diameter; when I wanted to cut off the end of a railroad car-bed I would make a long sausage-like torpedo by putting, say 20 dynamite cartridges in, one after another, putting an electric exploder in last cartridge at each end, tie both ends like a long stretch of Bologna sausage, then lay this along where it was desired to make a cut and cover it with mud, and when fired it would cut through the oak timbers and irons of a railroad car, the same as if they had been so much pasteboard.

Of a Bag-Torpedo.

One day I found a large mass to be shaken up, with fine chance for a blast, away down some 10 feet, but the only chance to get a torpedo down to the right place was between two large logs fast in the drift, and not quite 3 inches apart. While planning what to do I happened to disturb some white rags at my feet; picking it up I found it to be a fine, strong pillow-slip; dropping the closed end down between the logs, I made a man hold the pillow-slip open until I dropped eighty (80) dynamite cartridges down lengthways between the logs into the pillow-slip, then two exploders, and tied the mouth of the pillow-slip together, attached a rope and lowered the torpedo away down, guiding it to the desired place, and fired it with very satisfactory results.

Of a Box-Torpedo.

A great deal of our blasting was done by means of a box-torpedo. To prepare these we opened a 50-pound box (dynamite is always shipped in 50-pound boxes) and took out 15 pounds, leaving 35 pounds, then placed two exploders in it and filled the box with sand

or gravel to keep the cartridges altogether when lowered in the water, and nailed on the cover again; then by means of a small rope lowered it down in the water to desired place.

Of Blasting Logs.

It often happened that a large log with gnarled matted stump would project from the drift so that it must be dealt with alone. In that case, if the stump was chopped off and dropped into the water it would have lain still there, obstructing the water-passage, same as a large rock would have done. In such a case I had sometimes as high as 35 1½-inch holes bored 10 inches deep, and a ½-pound dynamite cartridge, with exploder attached, put into each, tamped with sharp sand and all fired at once, and this would often crush stumps to stove-wood size, and this would float off gently without further trouble. I should also mention the razing to the ground of a

Roman Catholic Church by Dynamite.

On the first Sabbath day after the flood Thomas McAnnalie, an employee of Booth & Flinn had it prepared for blasting. It had been a fine brick building, perhaps 70 x 100 feet, and of the usual height, with high brick steeple in front. The brick-work was still standing, perhaps 125 feet high, and the walls were still standing, but as every vestige of wood had been burned out of it on the first day of the flood, and its burning had no doubt lessened the strength of the common brick walls and they might fall at any moment, and as it stood on the edge of the track of the wave where thousands of people were passing every day, it was decided late on Saturday to blast it down, and by noon on Sabbath 25 holes had been drilled into the brick walls at proper intervals. Every person was cleared away for a space of 200 feet around, and the charges fired simultaneously. A belt about 1 foot wide and about 2 feet from the ground was pulverized and blown out, and the whole building and the pinnacles of the steeple and the walls gave a shiver and quickly melted down in an indistinguishable mass of brick, very few of them broken by the fall, and I would here recommend this same

Plan for Removing Dangerous Walls or Chimneys

left standing after a fire, because the dynamite merely crushes it, and the wall instantly drops without falling out, and the bricks and stone trimmings are left in far better condition than they would have been by any other plan of removal, but the grandest sight of all was the firing of

Four Hundred and Fifty Pounds

of dynamite in the drift at one time on the second Saturday after the flood. During these two weeks we had a constant swarm of newspaper reporters, representing every prominent newspaper in the country, who, on account of its novelty, naturally gave minute accounts of the drift and everything connected with it, and the country became alarmed, especially the cities such as Pittsburg, and as far as Cincinnati, who had no other water-supply than river water. Naturally, we were anxious to know that the drift and the dead bodies it was supposed to contain had been removed. During these two weeks everything had been done that men and money could do to expedite the removal of the drift. Ex-Governor Bigler had recommended them sending for 300 experienced loggers from his district in Clearfield county, who, he assured General Hastings, would clean it up in forty-eight hours, and they had been sent for and had come equipped with best cant hooks and pike poles, and after two days' trial had gone home disgusted with the job.

Then a young man, a Mr. Osborn from Altoona, with great pomp and profanity, assured General Hastings it was all nonsense to waste time removing the drift by dynamite, that he had a gang of men that could clean the whole thing up in a short time. General Hastings, being anxious to have it removed, gave him the job, and told me to stop the use of dynamite, as Mr. Osborn would remove the drift far quicker. I then put my apparatus and tools in store-room and went to bed for much-needed sleep, and in less than twenty-four hours a message from General Hastings directed me to resume the use of dynamite, as Mr. Osborn had given up the job. These were the conditions when, toward the close of the

second week after the flood, Governor Foraker, of Ohio, telegraphed to Governor Beaver, and Governor Beaver forwarded the message to General Hastings, urging that everything be done to remove the drift and its dead bodies. General Hastings and Colonel Douglass came to me on the drift, and, after consulting with them, it was decided to try a large blast. Up to this time we had directed our attention to cutting a canal, about 100 feet wide, up through the centre of the drift, and got to about 150 feet from the mouth of the Conemaugh Creek, which joins the Conemaugh river; this was about 600 feet from the stone bridge, and as there were no houses near to be injured by it, we prepared nine boxes, each containing 50 pounds of dynamite with 2 exploders in each box, and 25 to 35 feet apart; 3 across the breast of the drift at head of canal, and 3 across it about 35 feet back, and 3 more about 30 feet back of that again, and sunk all as deep as we could get them, from 4 to 6 feet under water, and fired all at once with the battery. The result was grand beyond description. Large saw logs and railroad ties and such like were tossed at least 100 feet in the air as if they had been chips; lighter articles were carried with the tremendous volume of water some 200 feet high. The river must have been drained to its bottom for at least 100 feet square to form the column that went up so high, and when it returned with its load of logs, etc., it produced a wavering motion in the water of the river which lasted a minute or more and shook the drift loose by the acre, which gradually drifted down, cleared it up to the junction of Stony Creek, and within a half-hour Governor Beaver was notified, and through him Governor Foraker, of Ohio, was notified that the Johnstown drift was opened through. It took several weeks after this to clear up the shores, as the water soon after this lowered rapidly, which added greatly to the trouble and expense of removing the drift-wood.

In conclusion, permit me to say, I fully believe that without the use of dynamite a greater portion of the drift at Johnstown would still be there untouched, and I have every reason to believe that much still remains under water and covered over with the sand and gravel which we shook loose from the drift, and naturally fell to the bottom. Before closing I must say I was very

much surprised at the evident ignorance of what appeared to be engineers of great experience in connection with dynamite. The simple pronouncing of the word dynamite in their presence appeared to make them shiver with apprehensive fear. That is a very disagreeable and foolish state of mind to be in. Every person, especially engineers, should know and always remember that all matter in the world is under certain fixed laws, and all we have to do is to understand those laws and obey them, and there is no danger with anything. For instance, no man understanding the laws governing oil and water would ever think of taking oil to extinguish a fire, nor would he ever take water to kindle a fire, but *vice versa*. So with dynamite. If you will only reflect for a moment that a very strong law of dynamite is that nothing but the sharp concussion of a peculiarily prepared cap or its equivalent of black powder or a ball from a strong gun can ever explode dynamite as now manufactured; I say if you bear this in mind it will free you from all fear or dread when dynamite is near your presence.

DISCUSSION OF THE PAPER OF MR. KIRK "ON THE USE OF DYNAMITE AT THE JOHNSTOWN JAM.

W. L SCAIFE: I should like to ask Mr. Kirk what proportion of nitro-glycerine his dynamite contained? And I should also like to know if it is not dangerous to handle frozen dynamite?

A. KIRK: As to the percentage, we use a variety of percentages. It is customary to estimate the strength of dynamite by the percentage of glycerine in the compound. As, for instance, 20, 40 or 60 per cent. means that there are that many pounds of nitroglycerine to the hundred, the remainder of the hundred being made up of sawdust and other absorbing ingredients. But what I used was made from a secret recipe, and the same rule does not apply in all cases. I should judge that all we used was equivalent to, commercially, 75 per cent.

As to the thawing of dynamite, of course our work was at a time of the year that did not require thawing, but I will mention here, for I suppose that is what the gentleman wishes, that all dynamite freezes at 42°, and in that condition is unexplodable

by any known means. The Prussians have gone very extensively into experiments about that, and have yet failed to discover any means of exploding frozen dynamite. But, if you will take notice, all the accidents that occur with dynamite are with the frozen article while in the act of thawing. In some very few instances, wilful carelessness is responsible. It is a common thing to expose frozen dynamite to a fire, and that is one of the most dangerous things you can do, or to lay it on a steam boiler to thaw it. That is a very dangerous act, for if it reaches a certain temperature, which is something approaching the temperature of steam at 60 pounds pressure, it will explode, and it will destroy the boiler.

The way I have found as most satisfactory for thawing dynamite is to have kettles prepared like glue kettles; the inside a removable chamber, water tight, in which you place the dynamite; that is surrounded by a body of water, say from 3 to 4 inches thick, and that in a vessel set on short iron legs, keeping it off the ground. You then expose the vessel to the fire, and you can charge that full for an ordinary quarry, and that will keep the dynamite thawed in the coldest weather, and you can use it the same as in summer.

W. L. SCAIFE: I have understood that there was some danger in using frozen dynamite, and so I asked the question. I may mention a case that came to my knowledge. A miner was using No. 1 dynamite which had become frozen, and, like most miners, he did not want to take the trouble to thaw it. He put a cartridge into a hole drilled in the mine, and it struck before reaching the bottom. He then drove it very hard against the rock. It exploded, and he was badly injured.

A. KIRK: Well, I may say about such cases that it is very difficult to get at the truth. For the last ten years I have made a special effort to find out the cause of every accident that I could hear of. We generally opened a correspondence, if we could do no better, with the postmaster at the nearest place to where the accident had happened, and we generally got the best information to be obtained. But there is a constant tendency among workmen to lie about cases of that kind. They will not tell the whole truth. Now, I will give an instance of that. We supplied dyna-

mite to open a drift up at Ben's Run, and a man was suddenly injured by a stick of our dynamite. That was published extensively, and in order to find out about it we made a special trip to get the facts. It turned out that the man was on the night shift, and he was about through. The rule was to do the drilling during the shift, and fire the charge immediately before the other shift came on, so that while one set of hands was retiring, the other could go on while the smoke had an opportunity to get away. Well, this man had drilled his hole and had got ready to fire, and here he found his dynamite was frozen. He grabbed up a half-pound cartridge, ran up to the entrance, blew up the blacksmith fire, and laid the cartridge on the fire. After blowing a little while he got tired and turned around, observing in doing so that there was a light as if it was burning. He picked up the cartridge, turned around to the anvil, and struck it against it. The cartridge exploded, tearing his hand and cheek, injuring him considerably. He was laid up for two or three months. I saw him afterwards, and he told me that his cheek inflamed and troubled him a great deal, and they had to poultice it. One day when they took the poultice off here were the fragments of a copper cap. How came they there? The only solution was that the shift before him had that dynamite ready to put in the hole, and the cap and fuse had become detached, leaving the cap on the cartridge. They had thrown it up on the bank opposite them, put in another cartridge and left the old one there. It was the cap which he struck against the anvil causing the explosion, and the fragments had been thrown into his cheek. So far as I am concerned, I feel perfectly safe in handling it all the time when it is frozen, or in thawing it. If you obey the laws connected with it there is no danger.

W. M. Phillips: I would be very glad to tell you all about this disaster, but of course you have all read about it in the newspapers, and after what Mr. Kirk has said I do not think there is much left. I was in Philadelphia when the disaster occurred. I received a message from Mr. Pitcairn, also others from General Hastings and Governor Beaver, requesting me to go to Johnstown to assist them. I had never had any experience of that kind

before, and do not think anybody else had. I met Colonel Douglass there and Colonel Sears of the regular army. Colonel Sears had been sent by the Government with pontoons. When we first went there General Hastings asked me if I would go down to the work. There had been so many suggestions made he hardly knew what to do. I went down, but between the dead bodies, the débris, and the disinfectants, it was almost impossible to stay there. I was very much disgusted, and wanted to go home when I saw it. I did not know where to begin. We divided the town into districts. I made a map of it and we sub-let the divisions out to the contractors. For instance, we divided the town into five districts. Cambria City and Morrellville was one district; the bridge and wreck another, and Kernville, Johnstown proper, and Conemaugh, which included Woodville, were the remainder.

Well, we began, as Mr. Kirk said, with all kinds of appliances. I had fifteen engines, most of them stationary, placed along the bank, using ropes and snatch blocks to pull away the débris. We put three engines on the bridge, pulling this way (illustrating). We found that we could not move the material. The wire in the river, I suppose, was the main cause. It was estimated at 150,000 to 200,000 pounds, and in coming down the river it had entangled itself amongst the trees and roots in every conceivable way. In that drift there was telegraph poles, street cars, dead bodies of horses, and everything you could think off. When I went there there was great opposition to the use of dynamite. I saw the absolute necessity of getting a channel through there, and went to General Hastings. He asked me if I thought we could cut through by Sunday, as on the score of health the matter was becoming very serious. I telegraphed to Pittsburg for 20,000 gallons of oil, and we tried burning, but that was useless. Then Colonel Douglass and myself held a consultation, and we told Mr. Kirk to go ahead; that we would take the responsibility. We began with small cartridges, and the result was very unsatisfactory. It would have done it in the end; no question about that, but the thing was not can it be done, but how soon could it be done. So on the last day I saw Mr. Kirk, and we resolved to go ahead with larger charges. The first charge was at 10 o'clock,

and was 400 pounds. It knocked down some chimneys, and the Cambria Iron people claimed they did not want the remains of the town destroyed, and threatened me with arrest. So I got Colonel Perchment to let me have a number of soldiers, to arrest any man found inside of the grounds when we were at work. This was done to avoid any one being hurt, as the place was full of relic hunters. About 2 o'clock we let go another one. They were going to arrest me, but I did not return for dinner. I went in the mines and took dinner with our men. At half-past two we let go another. Mr. Fulton, I believe, left his office, and about everybody cleared away. At half-past three we let go the last one we had, and the river was opened. We had a channel of an average width of 30 feet, with the water running perfectly free. It was opened three days from the time we began the work.

A curious thing about these charges we fired was the action of the dynamite; it did not seem to separate the drift or clear it, but it would cause the débris to fall right back again. It would clear a space as big as these two rooms, but, looking after the charge had been fired, we would not think it had done any good, but the moment the ropes were put to it it was a very simple thing to start it, and sometimes they started so quickly they would take a whole gang of men with them.

Well, there was the next difficulty—the worst difficulty of all. The drift, after being started, would clog at the bridge. I could not dynamite there except in very small quantities. But after we got that clear dynamite came into the very best use in the removal of the small drift-wood that we might build a bridge for the Cambria Iron Company to cross the Conemaugh opposite their great shops. It was necessary that they should get across to their metal and brick-yard, and we put up a temporary Howe truss bridge. We were greatly troubled with the logs lying there. We could not have gotten rid of them promptly with 50 cross-cut saws. I got some of Mr. Kirk's dynamite, and, I think, inside of two and a half hours, I cut nearly every log into small pieces, across the top or wherever I wanted them cut. We abandoned the saws, and in that way I cleaned the river nearly down to Sang Hollow.

When it came to clearing up the river above, we used dynamite

nearly altogether. When we got up opposite headquarters General Hastings asked me to make a channel there to prevent the water flooding the tents. We could not cut the wire, however, but, as it became detached, it sank to the bottom, and so we could make a channel there. We could not cut that wire while in coil. We pulled out all we could.

One great mistake, gentlemen, I will say here, as I said in the report I made to the State, the thing was a bungled job from the beginning. I mean by bungle that while the work of clearing was going on, and during the whole summer and fall, no attempt was made to locate a permanent channel for the Conemaugh river, the result being the river, after ordinary rains, floods a large area of ground, and it would have been much easier to dredge a permanent course before building was commenced than at present. The material taken out should have been used for raising banks on the sides of the stream. The material was principally gravel and pebbles, with a considerable amount of stone mixed with it. And in the shape the river has been left you will see next spring, when the snows melt, that they will experience great difficulties again. There is no river there. I will just give you an instance. They are building a bridge up there called number 6, above the Conemaugh. The contractor was to finish that bridge by the first day of November or forfeit $100 per day. He was getting along first-rate. He thought it was an easy job from the appearance. He dug down 12 feet. He came to where he found kitchen utensils, tin cans and everything of that sort, and he is still digging and has no foundation yet. That is the Conemaugh river to-day. The river is entirely changed. I told Captain Hamilton, who succeeded me, that it was all useless to make any special arrangements that were to be permanent. You can see all the way up to the dam, on the hillsides, the stones have been rolled over and over and the whole topography has been changed. The people do not seem to be aware of the change, and any attempts you make to change the course of the stream as it ought to be, brings out complaints of encroaching on somebody's property.

Of course, the immediate cause of the disaster has been removed. That cannot occur again; but in my judgment, and I do not think

I am wrong, I examined the dam carefully, and I do not think it could hold enough water to cause all the damage unless there was a great water-break back somewhere else. By water-break I mean, at some point distant back of the South Fork dam a large quantity of water must have come down in a solid body from a cloud-burst or some other cause, and this mass of water, together with the large volume already stored, was the cause of the terrible destruction.

A. E. HUNT: With the present river it would seem to be perfectly feasible to put in retaining walls, and let the stream, in a great measure, scour its own bed, only removing the large boulders. Is not there area enough to carry the stream as it is now?

W. M. PHILLIPS: You can hardly say the "stream." The whole course of the stream is still there, the position is still there, but the water does not run in the same path.

A. DEMPSTER: Has the bottom above the bridge been washed away?

W. M. PHILLIPS: Oh, yes, sir. To give you an instance: I saw Mr. Brown the other day, and he read me the riot act; said I was trying to blow down their bridge. And yet the depth of water was 22 feet. About 100 feet up stream from the bridge, where the water was about 6 feet above ordinary summer depth, this hole had the appearance of being scored out by logs, trees, buildings, etc., at the time of the jam.

T. P. ROBERTS: What was the original depth of the creek above the bridge?

W. M. PHILLIPS: About 6 or 8 feet. This mass of stuff came down and struck the bridge square and then came up. Everything was floating there. This formed an eddy. Where the street railroad went through, the river was nearly on the same level. It was all filled up, and the material was carried some 300 feet down and deposited there. Now, then, dynamite did not do that. I believe the Pennsylvania Railroad expected something of this kind when they built that bridge. It is not built perpendicular to the course of the stream. They put dowels on each course of stone on the face of piers below the water. They had placed sheet iron

or steel plates, and riveted it to the pier so as to protect the stone. Well, I found one of these plates away up stream. It could not have been blown up there. (?) But there is one thing you can see, that dynamite has done no damage apparently. The force of the explosion may have shown some signs of its shock in the cemented joints, but I failed to find any serious damage done. While I was in charge there were no shots of dynamite fired near the piers. Very small charges were fired near the abutments in *the drift*, and most of these were on the level of the water, or a few feet below. What was done after I left (early part of July), I cannot say. Mr. Hamilton, the engineer who took charge after I left, used dynamite about the bridge, but it was not in large charges, and I am told it was not close to the piers. I understood that Mr. Brown, of the Pennsylvania Railroad, issued positive orders to the effect that, for a specified distance which he named, no dynamite should be used. This was in the middle or latter part of July. The bridge is very badly burned by fire, and then, in some places, the face of the stone is cracked and blistered, but that does not hurt the bridge.

In that connection, if you will remember, the old bridge and the new bridge are not built on the same foundation. The force of the water took even the lowest course of the foundation stone of the old bridge, and yet some of these stones were found above or up stream.

A. Dempster: If you had 40 feet of depth of water you would certainly have a scouring force equal to that head to force a channel through the archways of the bridge, and it does not occur to me that there should have been any difficulty in clearing out that channel to the depth it was before.

W. M. Phillips: No, I think you are in error in regard to the facts. If there had been any means of carrying off the water that had fallen during the rain, a great number of persons would not have been drowned; but as it was, the water was 4 or 5 feet deep in the town before the dam broke, which prevented people getting away. Hundreds of people could have been saved if they could have gotten away from their houses to high ground.

A. Dempster: I am one of those of whom Mr. Kirk was

speaking as not being present to see the Johnstown disaster, but I do not profess to know more than those who were there, but I believe that I can account for that steel facing going up stream. The head of the water, being obstructed in its course by the bridge, formed a current in the opposite direction, and the force of it may have carried the steel casing away from its location to the point where it was found. Some years ago I had some experience in this direction on the Allegheny river at Oil City. The river was "bank full," and the current very strong. Six of us tried to stem the tide in a skiff. While passing round the head of a barge the five got scared and jumped on the barge with precipitation, and, in doing so, capsized the skiff, which was quickly swept under the head of the barge, and by coolness and agility the other saved himself. Whilst the skiff passed under, the others rushed to the lower end of the barge to see the skiff come to the surface and catch it, but they looked in vain, and, having given up the watch, they started to the shore, and in doing so they had to cross another barge which lay between the one under which the skiff was swept and the shore, and which lay nearly the length of itself above the outer one, and, on walking along, one of the party discovered the bottom of a skiff in the débris collected at the head of the outer barge which they thought would serve in lieu of their own that was lost, but, to their astonishment, when they took it out and turned it up, they discovered it was their own that they had looked for to emerge at the lower end of the barge.

A. Kirk: Perhaps I can throw a little light on the break on that pier. We had been blasting, and had gotten up about 100 feet from it, doing very nicely, but still there was a lot of stuff sticking just below the water, and no matter how we worked that would catch our other drift and stop it, and we concluded to put a blast down and remove it. This stuff turned out to be a lot of frame houses. We got rid of that, when we discovered what turned out to be a tree about 5 feet in diameter with a stump of tremendous size. It would have made a splendid mast. I had to blast it to pieces. This log was lying as if this was the pier (illustrating), and here was the stream running past the pier that lost its cut-water. That log was lying in just about that position to it.

The log had evidently come down and struck that pier and likely swung around against the shore and was lying there at the bottom of the stream where we did not think there was anything left. But the blasting of these old frame houses off the top of it caused it to jump up out of the water, and it had no doubt come down with the flood and gave that cut-water a slanting blow and loosened it. The cut-water must have been held in position by this sheet of steel you speak of. I never heard of it before. Well, that remained that way all the time we were blasting, and about the last week there was a lot of stuff banked up against this pier, something of a slanting position (illustrating). This log was catching everything that was coming down, and if we left it that way we saw it would soon form another jam on the bridge, so I concluded to put in a charge about 5 feet from the pier. I lowered it down on that slanting car-bed some 5 or 6 feet from the pier and fired it just before dinner. When we came back we found the channel open, but the cut-water on that pier had tumbled off, and no doubt it fell up stream. It could not be otherwise; and that might account for that sheet of iron being up there. But as to injuring the pier with the dynamite, that is out of the question, and I just happened to find evidence of that accidentally. I was standing talking about it, and inquring around, and finally I found the foreman of the masons. Mr. Houston, I think, was his name. I asked him about it. Said he: "Mr. Kirk, do not give yourself any uneasiness about that; I know that there was a crack 5 or 6 feet from the point of that cut-water, so that I could put my hand in it, before you fired a shot at the bridge." When I fired that shot which cut away that slanting sunken car-bed the pier cutwater tumbled up stream. I was taken to task very severely about it by the head lawyer and chief engineer of the Pennsylvania Railroad. I was surprised by their coming down to interview me; they were going to ride right over me, and hold me for doing that damage to the pier. I said my knowledge of dynamite enabled me to say the pier was never injured by dynamite; it could not be; the way the blasts were put off they could not have injured the pier. But they would not listen to that, and said they were going to hold me resposible for the damages. All right, said I,

you can just hold, but your head mason told me that before I fired a shot near that bridge there was a crack in the pier from the top of the cut-water as low as I could see, and I could put my hand in it. "All right, Mr. Kirk," they replied, "if he said so, you are free."

T. P. ROBERTS: I know dynamite to-night is the subject, but there has been a little wandering occasionally. One remark made by Mr. Dempster, in regard to the condition of the bed of the stream in regard to building dykes. I think that is the only solution for the preservation and safety of that town. During this winter they will be subject to floods, as they are having now, I believe. As Major Phillips has stated, the Conemaugh has wandered from its course, particularly so towards the upper end of the town. Its present bed is also higher than the old one, and greatly impeded with drift gravel, boulders, and débris of all kinds. What is needed is a new permanent course of ample section, to be secured in part by dredging, and in part by water-tight embankments. It is unfortunate that the owners of lots are likely to interpose objections to a wise system of improvements, but as the work will positively benefit more property than will be lost by condemnation, assessments ought to balance legitimate claims. It is possible, also, that certain streets might have to be changed; but no matter, the property will still be there, and more valuable than it is at present. Johnstown should appoint a commission with ample power, and should do this at once, for the longer the work is deferred the more it will cost in the end.

A. E. HUNT: I should like to ask a question on the general subject of dynamite, and that is to know if Mr. Kirk or any one else can give an intelligent reason why the action of dynamite seems to be almost invariably downward? Why is it so different from the action of, say, gunpowder? I had occasion once myself to use these explosives in blowing up an ice-gorge that was injuring a bridge. In a portion of the stream the ice had collected and made a solid wall to the bottom of the stream; in this location dynamite cartridges did the most good, breaking the ice up in large areas with every shot. But where the ice was thinner, gunpowder worked better, as the dynamite only broke the ice in limited areas around

each shot, while the slower working gunpowder shattered the ice much more. That is only an illustration. The question is, why is the action of dynamite, if there is any reason, more vertically downward in its action different from gunpowder?

A. KIRK: I may answer that by relating an anecdote that happened a good many years ago. Major Swope was United States attorney here. Dr. George Hayes, the chemist, was called as an expert to determine whether some damage had been done by black powder or dynamite. Mr. Swope put the question to him: "Mr. Hayes, will you please explain to the judge and jury the difference between the explosion of black powder and dynamite?" "Black powder, sir, does not explode." "Oh, I thought powder exploded." Mr. Hayes: "Some ignorant people think so, but it only burns."

That may be the solution of the whole thing. Dynamite is a chemical compound of bodies that have more or less affinity for each other. Black powder is a mechanical compound of ingredients that have no affinity for each other. It is merely put together mechanically. It only burns and that is one reason why people think that dynamite blows down more than black powder. I cannot, for the life of me, understand how an explosive substance can have more power downward than upward.

A. E. HUNT: It does.

A. KIRK: The reason I think is rather this: that black powder is of a different nature altogether from dynamite. The Prussian Government has spent immense sums to utilize dynamite as an instrument of war, but they have abandoned it now for the reason that its explosion is so instantaneous in all its parts that it does not give the ball time to start before it has shattered the gun that held it. Black powder begins to burn pretty quick, but it has a beginning, as is evident from the fact that when you want to test a gun as to what it will burn, it is a common thing with sportsmen to shoot over white sheets or over new fallen snow until they find unburnt powder, showing that it only burns. There was that much left unburnt when the pressure escaped at the muzzle of the gun. Now, my idea is, that the instantaneous explosion of dynamite produces more of a commotion than is made by black powder,

the idea being that the force will seek the weakest place to escape. The action of a dynamite blast is to make 8 cracks radiating from the centre as true as the spokes of a wheel. It will be said that you can see more of the result from a dynamite explosion than in the case of powder, but I do not think that the pressure can be any more one way than another, because when we want to make a successful blast in a side-cut, or along the side of a hill, we make the holes in a row, 10 feet from each other; that makes it that each hole has to exert a pressure only 5 feet when fired by electricity, until it meets the pressure from the other hole. That makes the bottom of the holes the weakest part, and finding vent in that direction the pressure is naturally downward. The blow of dynamite, I may say, is like the blow of a tilt hammer—it just strikes what it comes in contact with, and it does that so quick that the atmospheric pressure is sufficient to produce the action below.

W. M. PHILLIPS: I can give you another idea of that. We fired some small charges in front of the commissary department at Johnstown. Some one placed a good-sized stone on top of the dynamite (about 6 or 8 pounds), and this was fired a long distance, and lit on the roof of a building at the Pennsylvania railroad station, doing some damage. The stone must have gone 1800 or 2000 feet. This was below the Public School. During all the work while I was there I knew of but one accident, and that was to a man on the bridge, who was struck by a flying stone. He was not seriously hurt.

A. E. HUNT: Mr. Kirk has answered the question. I thought the same way, but I wanted to get his idea. In other words, all explosions of that nature are occasioned by the sudden expansion of what was a solid into a gas of very much larger volume. Now, with nitro-glycerine the formation of the expansive gas is almost instantaneous, quicker at least than with powder, and from ten to thirteen times larger volume of gas is produced; therefore, the action will be much more rapid than with powder, the powder taking a much longer time to be converted into gas of only $\frac{1}{13}$ the volume of the nitro-glycerine gas. The quickly expanded gas finds its line of least resistance upwards, and therefore does not exert as much force in a downward direction. The difference is

that the one agent resolves itself into an explosive force more rapidly than the other, and develops a much larger volume of expanded gas.

T. P. ROBERTS related a laughable incident of his first experience with dynamite when trying to raise a rock on Herr's Island. He dug a hole under the rock, put in his cartridge, and filled up the hole with gravel. The natural effect was of a cannon, and boulders and gravel flew in all directions. It created so much excitement that he thought it best not to relate it before.

J. A. BRASHEAR related and illustrated on the blackboard the result of some experiments made by Prof. Munroe of the Newport Torpedo Station, where a number of cartridges were exploded on steel plates that had been hardened. Suppose we have here a cartridge and there is a conical depressión in it. When this cartridge was exploded upon the plate, one would naturally expect that if there was a depression in the cartridge that there would be an elevation left in the steel plate after the explosion, but in every case the reverse took place, and there was a depression that corresponded to a depression in the bottom of the cartridge. Probably twenty steel plates were used, and the result in each case was the same. I do not attempt to explain this curious phenomenon. At the meeting of the American Association of Sciences, where the paper was read and the result of experiments shown, some tried to explain it on the principle of the "resolusion" of forces.

He also spoke of an explosion in his work-shop of fulminate of silver, by which almost everything breakable was destroyed, but strange to say the windows were not shattered in the least.

A. KIRK: I would repeat, that dynamite only affects the parts that it comes in immediate contact with. It is local in its blow. It is working a complete revolution in marine work, and can be used where black powder cannot. You can put it down in the water without anything around it at all except the manilla paper, and fire it with perfect success. In fact, I had intended to embody in my paper that one day I lost two 50-pound cartridges. I was getting them ready to fire in a place where the current was very swift, and just as we got ready to touch them off here came

a lot of drift wood, cut away the wires, and took the boxes down stream. I offered a reward of two dollars a box. We afterwards recovered both of them and I fired them. It had lost but one-half its original strength after being in the water a week. I also tried some that had been washed from the stores in Johnstown that had been through the flood, and had been in the water for some considerable time, and I believe it was just as strong as when first made.

A. E. HUNT: On the subject of danger in handling dynamite, I have an illustration. I had a friend who was connected with the Chester works something like five years ago. The question came up in my professional work of testing the relative amount of nitro-glycerine in a lot of different makes of dynamite. My friend, the chemist of the explosive manufacturing works, had also made some analyses, and I had written him saying the method he had used was rather a dangerous one in the way he separated the nitro-glycerine. He wrote back saying that there was no danger; that he had just as lief handle it as butter or oil. While that letter was in the mails, before I had a chance to read it, I read in the papers the account of the blowing up of his factory and his death, so that even if a man knows how to handle it, nitro-glycerine is a dangerous thing, and I trust my friend Kirk has not created an impression in the minds of any one present that it can be handled, even in the shape of dynamite, as you would "butter or oil."

F. C. PHILLIPS: The curious fact Captain Hunt has mentioned, that dynamite seems to exert its force principally downward, may have another explanation. Some time ago Mr. Frank Dupont, of the Wilmington powder works, told me that experiments they had made at their works led them to believe that nitro-glycerine, at the moment of explosion, may cause complete vaporization of surrounding solid bodies, so that explosion of nitro-glycerine actually tends to induce an explosive change in such apparently stable and harmless substances as common salt and sulphate of magnesia.

These substances undergo so complete a dissociation or disruption that they may be said to explode. When a dynamite cartridge is placed on top of wood or rock, as in blasting, it is possible

that these hard resistant bodies undergo a more or less complete volatilization near the point of contact. The air above the cartridge is too elastic to propagate the shock in its original severity. The shock seems to be greatest downward because that is the direction in which it meets with the more or less inelastic resistance of solid bodies.

W. L. SCAIFE: Outside of the chemical influence Mr. Phillips has just mentioned, it seems to me that the explanation of the physical effects may be put a little more simply. The expansion of dynamite is so rapid that, when it rests on a solid substance, the air forms a sort of wall or buffer, which causes the gases to react downward. If there was no atmosphere, or if the explosion occurred in a vacuum, the gases would expand to fill the vacuum, and would produce no effect on the supports except that due to their own weight. I have seen holes in hard rock filled with cartridges of dynamite, but covered with nothing except the air. Their explosion would produce a certain amount of broken rock. When the holes were tamped with water, the effect was still greater. Similar holes filled with dynamite, and strongly tamped with clay, were much more effective than the preceding. In short, the downward action of dynamite depends on the pressure or confinement to which it is subjected.

EMIL SWENSSON: I once had an experience with dynamite, in which case it acted solely in an upward direction. I was then in charge of the opening up of a new feldspar mine on the west coast of Sweden. Powder was first tried, but without satisfactory result; indeed, hardly with any visible effect on account of the crystalline structure of the mineral, the products of the powder explosion filling the interstices simply. Dynamite was next used and well tamped in, and the result of its explosion was something very beautiful. Around each hole a funnel or rather an amphitheatre had formed, the feldspar having split in right-angled benches, beginning a few inches above the bottom of the drilled hole.

Society adjourned about 10 o'clock.

S. M. WICKERSHAM,

Secretary.

DECEMBER 17TH, 1889

SOCIETY met at 8 o'clock P.M. President Brashear in the chair. Vice-President Scaife; Directors, Becker and Metcalf and 28 members and visitors.

C. I. McDonald and J. R. Reed were duly elected to membership.

The following paper was read on

STONE USED FOR STRUCTURAL PURPOSES IN ALLEGHENY COUNTY, PA.

BY ALFRED E. HUNT.

THE writer is very glad to record the fact that the large buildings of Pittsburg are very properly being built almost entirely of granite, sandstone, or brick, as these three materials form the most lasting masonry, in almost every climate, but are especially adapted for a large manufacturing city like Pittsburg. Except for the public spirit and decisive action of members of our chamber of commerce, some of whom are members of our Engineers' Society of Western Pennsylvania as well, we should have had probably a limestone building instead of the granite structure that is progressing slowly—but we all trust, surely—towards completion for the Government Post Office and United States Courts.

Limestone or even marble, which is a metamorphic variety that is susceptible of taking a good polish, will very soon deteriorate in an acid atmosphere, such as is ours. Our City Hall is built of a white sandstone; although it is a monument of the old smoky days of Pittsburg before the advent of natural gas, and one would not know from its looks that it had ever been white, it was quarried some twenty miles up the line of the Allegheny Valley railroad; a stone that quarries easily and is susceptible of being dressed smooth, as is evidenced by the front of the City Hall. This stone hardens considerably on standing, and is an excellent building stone.

Trinity Church, on Sixth Avenue, and the German Evangelical

Church on Smithfield Street are built of Massillon, Ohio, sandstone. It has not weathered very well, and does not bear evidence of being a very durable stone.

The Masonic building and the Duquesne Club are of red Connecticut river sandstone from Massachusetts.

The Marine National Bank and the Grant Street Lutheran Church, the East Liberty Presbyterian Church and Moorehead residence, Ridge Avenue, Allegheny, are built of varying colors of Beaver Valley sandstone, one of the best; and on account of its abundance and of its proximity to Pittsburg, also one of the cheapest building materials for ordinary masonry work for our district. This stone is close-grained and somewhat uneven, and does not admit of a very smooth finish in dressing, and is not susceptible of being polished at all. At the same time, in the above-mentioned large fronts, it compares very favorably for beauty with granite; and to the taste of the writer, it is infinitely superior—its rugged face speaking of honest endurance and strength—to the smooth surface of marble or the fine finish of limestone, with its lack of durability.

The writer is not aware of a single large building in our district built of limestone or marble—a fact that is quite remarkable for a district of its size.

The Allegheny County Court House is built of granite from Stoney Creek, Mass., and its inside stone work is mostly of Beaver County sandstone. The Fidelity Title and Trust Company building, the new Post Office building, the German National Bank, the Pittsburg National Bank of Commerce, the Keystone National Bank and the Hussey building are built of granite, most of them of the white granite of Hallowell, Maine.

The Westinghouse building on Penn Avenue and Ninth Street is built of brick and terra cotta, and granite from Belfast, Maine, and the Schmidt building of brick and red Scotch and Quincy granite.

Marble from around Rutland, Vermont, is used very largely for inside decorations, as well as the celebrated white marbles from Italy, and of late years, a rather coarse-grained gray marble from Georgia has been extensively used.

The well known pink and variegated marbles of Eastern Tennessee are much used in interior decorations as well, and would have much larger uses were it not that they are so unsound, much loss being occasioned thereby in sawing and otherwise working them.

The Ligonier quartzite, found in the Ligonier Valley, and, in a pink variety, on the line of the Baltimore and Ohio railroad, is an excellent hard and durable stone, and is an illustration of the fact that unfortunately our most durable stones are so extremely hard and difficult to work, having no natural cleavage planes, as to make them expensive and almost impossible to use in dressed masonry work. This stone, like the trap rock and older crystalline or metamorphic primitive quartz, makes excellent road metal, street pavements or ballast, but is so hard and difficult to dress as to not only make it very expensive for building materials, but also, where dressed stone are necessary, not durable as well, for they are so hard as to crack often in being dressed, these fine splits or cracks absorbing moisture and afterwards splitting out the stone by the action of the frost.

The table of qualities (page 152) is found to be about the average of the building stone used in our district.

The modulus of rupture in transverse strength was found by the following formula:

$$R = \frac{W}{\frac{2\,bd}{3\,l}}$$

The co-efficient of transverse strength was found by the following formula:

$$C = \frac{W}{\frac{bd}{L}}$$

The relative value of the crushing strength to the size of the cubes tested corresponded quite approximately to Gen. Gilmore's formula of $Y = A \sqrt[3]{X}$.

A = Crushing pressure of an inch cube of the same material.

Y = Total crushing pressure in pounds per square inch.

X = Length in inches of edge of cube under trial.

b = Breadth in inches.

d = Depth in inches.

l = Length in inches.

R = Modulus of rupture in pounds per square inch.

C = The weight in pounds to break a bar an inch square and one foot long between bearings.

Kind of stone.	Weight per cubic foot in lbs.	Rel'tive loss under exp'nsive action of soda-sulphate test, hard burn'd brick being taken as one.	Weight of water absorption of dry stone in per cent. of weight of stone.	Specific gravity.	Coefficient of elasticity.	Coefficient of transverse strength.	Modulus of rupture.	Crushing strength of two-inch sawed cubes in lbs.	Ultimate crushing strength per square inch, in lbs.	Ultimate crushing strength in tons per square foot.
Vinal Haven, Me., granite..	165	1	0.66¾	2.62	5,500,000	100	2000	80,000	20,000	1440
Concord, N. H., granite.....	175	1	0.33	2.64	8,000,000	110	2200	76,000	19,000	1368
Gloucester, Mass., granite ..	168	1	0.33	2.58	6,500,000	115	1800	72,500	18,100	1303$\frac{1}{10}$
Quincy, Mass., granite........	170	1	0.20	2.62	8,500,000	110	2100	82,000	20,500	1476
Beaver Valley sandstone, green with quarry sap.....	150	5	2.00	2.38	....	75	1300	48,400	12,100	871$\frac{1}{10}$
Same dry after being weathered	140 to 145	5	4.00	2.40	5,000,000	70	1200	56,000	14,000	1008
Connecticut River brown sandstone......................	140	11	2.00	2.60	....	75	1400	42,000	10,500	756
New Jersey brown sandstone.............................	145	12	3.33	2.50	....	70	1200	32,000	8,000	576
Lockport, N. Y., gray limestone..............................	150	10	1.00	2.70	5,000,000	90	1500	48,800	12,200	878
St. Albans, Vt., white marble..............................	170	2	0.33	2.68	2,500,000	120	2000	74,000	18,500	1332
Italian white marble..........	165	2	0.33	2.65	2,700,000	125	2200	76,000	19,000	1368
Georgia gray marble.........	158	3	0.80	2.60	2,300,000	100	1700	66,000	16,500	1188
East Tennessee pink marble	165	5	1.00	2.65	2,900,000	120	1900	70,000	17,500	1260
East Tennessee variegated marble............................	160	9	1.00	2.70	2,000,000	80	1100	42,000	10,500	756
Hard pressed brick	150	1	2.00	2.15	4,500,000	50	1100	34,000	8,500	612
Common building brick average	120	12	12$\frac{1}{10}$	2.10	3,000,000	40	900	32,000	8,000	576
Granite from Petersburg, Va..................................	165	1	0.50	2.62	....	......	......	100,400	25,100	1807$\frac{1}{10}$

W = Concentrated load applied in centre plus one-half of the weight of the beam itself in pounds.

L = Length of the beam in feet.

Baker, in his work on *Masonry Construction*, gives the following estimates of safe pressure loads for different kinds of masonry:

Concrete, 5 to 15 tons per square foot.

Rubble, 10 to 15 tons per square foot.

Squared stone, 15 to 20 tons per square foot.

Good brick laid in lime mortar, 15 to 20 tons per square foot.

Good brick laid in cement mortar, 20 to 30 tons per square foot.

Limestone ashlar, 20 to 25 tons per square foot.

Granite ashlar, 30 tons per square foot.

In actual practice in our district the loads are nearly all of them less than the least figures quoted, the maximum load allowed on any of the sandstone bridge piers in the district being not over 250 pounds per square inch, or 18 tons per square foot in any case.

The Beaver Valley sandstone most used for bridge piers is capable of sustaining a load of from 25 to 30 tons per square foot, if precautions are taken that the loads shall be uniformly distributed, and if the loads are not applied until the mortar in the masonry has had time to become thoroughly dried. It is this precaution especially, both in masonry and brick work of buildings that more care should be taken with in our district. The disaster at the Willey building was a terrible illustration of the necessity of allowing mortar to become thoroughly dried out before placing on it great superincumbent weight and surface having to withstand wind pressure. In wet weather it often takes many weeks before the mortar has become even reasonably dry and coherent enough to give any bond whatever.

Where high walls are to be erected with great speed, a good portion of quick drying cement should be mixed with lime mortar, and great care should be taken with the mortar and the method of laying the brick, recognizing the fact that the mortar joints are by far the weakest points in masonry. The bricks should be pressed into the mortar so as to force the mortar into the interstices near the surface of the brick to strengthen the adhesion.

	Lbs. per cubic ft.
Hard pressed brick, with their joints, weighs,	145
Soft brick, with their joints, weighs,	100 to 125
Concrete masonry weighs,	130 to 160
Dressed granite, with mortar joints, weighs,	150 to 165
Dressed limestone, with mortar joints, weighs,	150 to 165
Dressed sandstone, with mortar joints, weighs,	135 to 145
Ordinary mortar weighs about,	100

Stone for structural purposes may be classified into natural and artificial stone.

Natural stone may be classified according to their physical structure and according to their chemical composition.

According to their physical structure, rocks are either stratified or unstratified. The stratified rocks are of the more recent geological formations, and were deposited as sediment or drift from water, in layers of plain divisions of often unequal thickness, some of them being only $\frac{1}{8}$ of an inch in thickness, others of many feet of thickness.

Pittsburg being situated in the centre of the vast coal measures of the Palæozoic basin, the great majority of the stone found in the vicinity are of a sedimentary or stratified character. Some of the more compact of these stones make strong and durable building stones, as the sandstones of the Beaver Valley. But, as a rule, the stratified stones are not as durable or as strong as the older unstratified rock, one reason for which is, that these older rock of igneous or metamorphic origin, found near enough to the surface to be quarried, have stood the test of ages, and are the survival of the fittest, being by their very existence an evidence of their durability; the softer, more easily decomposed rocks, formed contemporaneously with them, having been eroded and worn away, becoming in many cases "the stock" from which the newer stratified rocks have been formed. In other words, Allegheny county is rather handicapped by its geological position in the matter of prevalence of many kinds of good, durable and strong building stone.

The stratified rock have the following varieties:

I. Fine crystalline, example marble. There are many of these stones which are both durable and strong; none, however, are found nearer to Pittsburg than Tennessee or Vermont.

II. Coarse granular crystalline, in which the grains adhere firmly together, as in gneiss, or are cemented together, as in sandstone, by some cementing material. Some of these stones are compact and durable; most of them, however, are porous, friable and weak. There are many varieties of this sort of stone in our neighborhood.

III. Compact granular structure, in which the grains are very fine, and firmly adhere one to the other. Most of these stones are strong and more or less durable. Our best sandstones and limestones are of this class.

IV. Porous granular structure, in which the sub-divisions of the stone are coarse and loosely bound together. The vast beds of clay shales in the coal measures are illustrations of this kind of stone. They all have a very low degree of strength and durability. Many of these stones have Palæozoic shells bound into their structure.

V. Slaty structure, easily split into layers, which are not necessarily along the lines of stratification, but according to certain cleavage-planes, occasioned by pressure and strains produced in the stone by geological action. Most of these stones are very weak and easily broken up, and, like the stone of the class mentioned above, often make very untrustworthy foundations upon which to build masonry. There are vast deposits of this class of stone in our vicinity.

VI. Conglomerates, where the material is non-homogeneous, nodules of one kind of stone being imbedded in a matrix of another. The writer does not know of any of the stone of this class that are good building materials found in this district, although some of the conglomerates found in the eastern portion of the State make good structural stone, and the celebrated Roxbury pudding stone of Eastern Massachusetts is highly prized as a durable building stone.

The unstratified building stone are mostly of compact crystalline structure; granite, trap, and basalt are good illustrations of such rock.

According to their chemical composition, building stones are mostly of three classes—siliceous, argillaceous or calcareous.

The siliceous stones have over 50 per cent. of their constituent parts silica. Such stone are mostly crystalline or fine granular, and are the most durable rock we have. The principal building stone of this class are granite, syenite, gneiss, basalt, greenstone, trap, quartz, sandstone, mica or hornblende slate.

The argillaceous building stones have clay or a silicate of alumina as a prominent constituent; porphyry and clay slate are among

the most prominent stones of this class. There are not very many durable stones among them. In fact, an argillaceous stone is almost a synonym for a very unenduring one. One of the defects with almost all stones of this class is that they absorb moisture freely, and are consequently injured by freezing and thawing.

Calcareous stones are those in which lime predominates mostly as a carbonate or silicate. Many of these exist as very pure carbonates of lime, as marble and many grades of limestone. Others are combined with magnesia carbonates, and in this case are called dolomites. These dolomites are, as a rule, much more durable than the ordinary limestones. Others of these have considerable sand, clay or oxide of iron mixed with them.

In some cases, where the stone is not subjected to the action of acids, and where the calcareous particles are firmly bound together in a compact mass, these stones are very durable; but in the moist and acid atmosphere of a large manufacturing centre like Pittsburg, subject as it is to the extremes of heat and cold, by which the minute interstices of the stone are alternately attacked by corrosion and by the disintegrating power of freezing water, limestones are comparatively short lived and not durable. The same remark also applies to sandstones in which the cementing material has much lime in it, or has much hydrated sesquioxide or protoxide of iron, clay, or organic matter contained in it, for such substances are more or less rapidly eaten out and cause the disintegration of the entire rock.

The agents which attack the lifetime and strength of a stone in our vicinity are:

Variations in temperature, by which the particles of stone are alternately expanded by heat and contracted by cold, causing a moving of the particles of the stone one upon another, and a loosening of the binding or cementing qualities of the material, or, more seriously still, by the freezing of the absorbed water and consequent expansion of the ice, acting like a wedge to throw the rock faces apart.

Rain, which in Allegheny County becomes considerably charged with carbonic and sulphuric acid, acts as a solvent of the cementing portion of many building stones. Stratified stone should

always be laid with its layers of stratification, or, as is said in many masonry specifications, with its natural beds horizontal, for in this way the solvent action of the rain is less upon the stone. Laid the other way, each line of stratification becomes a furrow or channel, down which the water will run, and corrode and disintegrate the material.

For bridge piers and abutments, retaining walls and pavements, the wear of constant friction is a serious cause of destruction, and for such work special care should be taken that the rock selected should be tested as to its power to withstand attrition in the various ways in which it is likely to be subjected. Some sandstone, for instance, which will serve excellently well to withstand the friction of water in a rapidly moving stream, would still wear out very rapidly for pavements; hardness and weight both are required in such work.

In some of our older buildings, vegetation should be noted as one of the causes of deterioration of rock, especially as it is built up in masonry; the intruding creepers of vines, lichens and mosses seeking out the interstices in the rock, and enlarging them and then decaying, giving to the water that percolates into these small places added chemical strength as a solvent to the cementing portions of the stone; and in most kinds of stone it is this cementing portion of the rock that gives to it strength and durability as a whole, but unfortunately in most rocks it is also this cementing portion of the material which is the easiest taken into solution by water charged with various acid, or organic alkaline chemicals.

The best qualities to be looked for in a building stone are, to be not easily acted upon by chemical action; hardness, compactness and solidity combined with ability of being cheaply quarried and dressed, and non-absorption of moisture.

One of the best ways to test these qualities is to note the action of the weather upon the rock in exposed portions at the quarry, taking into consideration the way the rock lies, and the probable treatment to which it has been subjected, and the varying atmospheric changes to which it will be subjected in its proposed new site in our acid, moist and alternately warm and cold atmosphere,

from the pure and perhaps naturally even and dry country atmosphere in which it has perhaps stood finely, with sharp edges and old surfaces, having apparently stood for ages without being deeply corroded. This point is well illustrated in the famous Cleopatra's needle, which has stood for ages, a finely hewn and engraved block of syenite in the dry and even atmosphere of Egypt, and which is now rapidly deteriorating in the moist and acid atmosphere of New York City.

Some forms of rock harden considerably by exposure to the atmosphere; the cementing material of the outside faces of the rock forming very hard hydrated masses, which aid a great deal in the preservation of the rock.

Some forms of rock need to be weathered to allow them to dry out. Such rock will often lose from 5 to 10 per cent. in weight from drying out of "sap water." Our Beaver Valley sandstones are very good illustrations of the above. They are much softer and more friable, and are much more easily worked while the quarry sap—a solution of silicate of soda, together with some silica held in solution by organic matter—is still in them. After allowing them to weather for a year they become much harder, and seem to harden gradually for years after being quarried, by the gradual precipitation of the silica in the water of hydration contained in the rock. Some stone dries out much more rapidly than others, due to its peculiar structure. The writer has noticed this phenomenon even with bridge piers where the rock has been under water, that the Beaver Valley sandstone gradually hardened after being quarried, if allowed to weather for a time at the quarry before being laid in the work.

The writer believes, in the case of these sandstones, that the difference is in the losing of a part of the water of hydration, that is the chemically combined water in the silicates of the binding material of the rocks, making this binding material much harder and consequently making the rock much stronger.

Microscopical examination of thin cuttings of the rock will tell very considerably as to the quality of the binding cement as well as the character of the minerals, often a good many in number, comprising a building stone. With a knowledge of the character

of the minerals and the way they are bound together, considerable has already been done, and much more can be done to aid our knowledge of the durability of various building stones.

Absorption tests of the relative amount of moisture absorbed by a given quantity, say a cubic inch of building stones, is of considerable use. A stone having a large absorption power will generally form a very unenduring stone in a climate like ours, subject to the expansive heavings of frost and ice. Another test of similar character is to saturate a weighed portion of the stone to be tested in a concentrated solution of sulphate of soda, and afterwards dry in a warm atmosphere; the sulphate of soda crystallizing in the pores of the rock will have an expanding action somewhat similar to that of frost. The salt solution is then washed out by repeated soaking in warm water, the specimen dried and the loss by weight noted. In this way the relative loss of various kinds of stone will give an approximate idea of the relative durability under the action of frost. These tests, however, show with sandstones what has been confirmed by experience, although it would at first seem somewhat anomalous that the coarse-grained sandstones, especially of the Beaver Valley, stand better the action of frosts than the finer, closer-grained sandstones, like the brownstone of the Connecticut Valley, although the coarser-grained stone absorbed considerably more moisture. This is due to the stronger, closer combination of the cementing material. The color and a close examination of the surface of a sandstone will tell considerable as to its durable qualities. Feldspar, distinguished by its fine grain and compact structure, is especially bad, as it more rapidly decomposes. Clay also is bad, and a blue-colored limestone, colored with clay, which is a prevalent country rock in our district, and much used for cellar foundations of dwelling houses, should be avoided for exposed masonry work as weak in its power to withstand the ravages of time. The best and most durable sandstones are light in color, close in texture, and free from streaks of clay or other impurities (called by the quarrymen "dries"). Limestones not only absorb more moisture, but lose more weight by the expansive action of frosts, or of the soda sulphate solution, than do sandstones. Hard granites

and compact crystalline marbles absorb the least moisture of all, although in the case of marbles, owing to its brittleness, there are almost always fine cracks in it which absorb moisture, and in such cases they are very weak to the action of frost.

The crushing strength of stone is most often referred to as the relative "strength" of a stone for building purposes. This is by no means the crucial test of the strength of a stone, when by the word "strength" we mean to add, as it often does, to those who do not look into the matter carefully, the durability of the stone. As pointed out before, its solubility, hardness, compactness, and closely knit cementing qualities, its failure to absorb moisture, and its uniformity, should all be taken into consideration with its crushing strength per square inch in thus speaking of its strength. The crushing strength of stone is usually determined in cubes of 2 inch base. It is important in comparing the relative crushing strength of a series of stones that the size in which they were crushed be reasonably the same. This is not absolutely necessary, for if the stone be reasonably homogeneous the results should be comparatively the same, although inequalities in the bearing faces would much increase errors by comparing cubes of various sizes. It is best to use every precaution that the pressure be uniformly applied to the bearing face; to this end it is the writer's practice to place many layers of thick blotting paper directly above and below the cubes to be tested, and to also test both under and over a smooth surface of soft pine wood, and to note that the indentation in this wood is uniform and equal in depth. All stone should be tested relatively the same way as to its location in the bed-rock, as stones are always much stronger with their bed-faces laid down. Specimens should always have their bed-faces properly marked upon them with a pencil.

Sawed specimens always give better results than those chiselled out by hand, and the facts of the way the specimens are prepared should be noted on the report of the tests, and should be taken into consideration in comparing various results as to crushing tests of stone. These results often vary as much as 25 per cent. or more, whether hand-dressed or sawed to shape. The way the rock breaks should always be noted under remarks upon crushing tests, as the

facts give some idea of the character of the stone; hard homogeneous crystalline, or metamorphic, rock cubes snapping off sharp, often with considerable violence, the break starting in the centre of two opposite vertical faces of the cube as it is being tested, the lines of the cracks running off in sort of pyramids or cones to points near the corners of the faces taking and bearing the pressure; the portions of the faces outside of these lines with a thickness sometimes from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch being thrown off for some distance. Softer, more granular rock do not act in this way, but seem to cripple and bulge out in the centre, while non-homogeneous material gives way at the points of demarcation of the weaker materials.

Stone, as it is cut out from the quarry in irregular shapes, is called rubble. Most cellar foundations of dwelling houses are built of this kind of stone, cut from the country sandstone into pieces whose weight is not too great to be handled by one mason in laying. That portion of the rock cut off in irregular shapes in squaring the blocks is called "spalls." These "spalls" are used in heavy mason work to fill the interstices between the irregular course rock, and is called "backing." It is relative to the leeway allowed in the use of this backing with rough mortar that most of the poor mason work is found. These spalls are also used for lining the bottom and side walls of streams, to prevent the water cutting or scoring the earth from under the mason work. Such use of it is called "rip-rap." Most of all the bridge piers in the rivers of our district are protected by "rip-rap."

Building stone are usually roughly squared at the quarry to give good joints, and are face hammered on both top and bottom beds. This is popularly called by quarrymen "dressing the stone to beds and joints." When the stone are allowed to go into the work in this condition, as they often are in rough masonry, as in bridge piers, abutments and the like, it is called in the specifications generally "quarry-faced stones." Nearly all of our bridge piers and retaining walls are built of quarry-faced stone.

When for a space of an inch or so from the edge the stone is dressed approximately true to given dimensions and the rough projections are cut off with a pitching tool to a given distance

from the edges, they are called "pitched-face stone." Most of the sandstone used in our buildings are pitched-face stone.

"Drafted stones" are those in which the surface around the edges are made very smooth, and edges are made exact to dimensions with a chisel-draft. This is a favorite finish for the granite blocks in many of our public buildings.

The dressing of the surface of the stone in our buildings is either "rough pointed" or "fine pointed," according to the amount of projection allowed to remain; the dressing being accomplished with a pointed tool of round or octagon steel, with blows of the hand hammer or mallet; "pean hammered," if chiselled to a finish with a pean hammer; "bush hammered," if smoothed with a flat hammer; having many points on its face, called a bush hammer. There are very few of these latter mentioned varieties of finish on our Pittsburg masonry, as the stones used are so coarse as not to admit of them.

With marble, sandstone, and some of the softer stones, the faces of the blocks are sometimes sawed to a smooth face and the blocks afterwards rubbed smooth.

Ordinary brick are made by pressing mixtures of clay, with more or less sand, into rectangular blocks of regular sizes, and, after drying out, heating in kilns until the structure becomes semi-vitrified. Such brick made from our own native clays, together with tiles and terra-cotta work for ornamentation, are about the only variety of artificial stones used in the Pittsburg district, with the exception of masses of concrete used in the foundations of some of the iron and steel mills. This concrete is not as often used as it could be advantageously in mill foundations. The writer believes that large concrete blocks built *in situ* with protected binding bolts to hold the blocks firmly together and with suitable wells to get at the broad base washers and bolt heads form the best kind of mill foundations. They are nearly as cheap in first cost as brick work, can be readily cut apart, and, if built conveniently with grooves in the middle of the blocks, they can easily be handled in taking down the foundations.

Ordinary brick, chemically, are silicates of alumina, with some

silicates of lime and magnesia, and oxide of iron; the latter constituent giving to the brick their well-known red color.

Clay fire-brick are made in a general way similarly to red building brick. They are made of purer clays containing less oxide of iron or alkalies, the sum total of which should not be over 3 or 4 per cent. in good fire-brick.

Silica fire-brick are made of ganister rock, bound together with milk of lime and well pressed and calcined at a very high heat. The amount of lime should not be over 3 or 4 per cent. of the weight of the silex.

The requisites for good brick for building purposes are that they should be fine, compact, and of uniform texture and color. They should be hard and give a clear ringing sound when struck a sharp blow. They should have a specific gravity of at least 2.00. When whole brick are air-dried for three days in a warm room and then weighed and afterwards immersed in water in the open air for forty-eight hours and dried in the air until the surface becomes dry, say three hours, and again weighed, the increase in weight ought not to be over 10 per cent. from absorption of water. The brick should have plane surfaces, parallel sides, and sharp straight edges and reasonably accurate right angles.

The crushing strength of full-sized brick when ground flat and pressed between thick metal plates, distributing the load uniformly, should be at least 280,000 pounds, or 8500 pounds per square inch. The modulus of rupture of the brick should be at least 1000 pounds per square inch. The size of the brick should be close to 8¼ inches by 4 inches by 2¼ inches, and the weight should be 4½ pounds each, or 120 pounds per cubic foot of brick.

The use of pressed brick in various fancy shapes, and even of carved work in brick and terra-cotta, has come much into vogue of late, and very neat and attractive designs have been executed within the past few years, both in residences and some of the large building blocks of the city.

The increase of ornamentation and pretense of ornamental architectural designs in large office buildings, stores, and other business blocks in our city, in stone and iron buildings, is a very favorable indication of the prosperity and growth of our city.

There are many very handsome building fronts of iron in Pittsburg, as well there should be in "the Iron city."

The writer has hopes later of seeing aluminum castings as well used in the ornamentation of our large building fronts, as this metal casts readily into any desired shape, is as strong as cast-iron and will hold its lustre without tarnishing.

Discussion of the Paper of Alfred E. Hunt on Building Stones of Allegheny County.

Max Becker: It does seem rather strange that this particular part of the country, which is so very rich in minerals of almost every kind, should be so destitute of good building material. I have often had occasion to notice and to regret this; because, whenever we want to do any work requiring masonry, we have to ransack this whole country in order to find suitable material. But perhaps this scarcity of a much-needed article of daily necessity has some redeeming feature in this, that in a city where some specially good building material abounds, its use becomes universal, and the architecture generally assumes a dead uniformity and a monotonous appearance; whereas, here in Pittsburg, where we must draw our building supplies from the country at large, the variety which is being introduced into our architecture is producing a pleasing effect, although it is no doubt accomplished at the expense of the enterprising gentlemen who are doing the building.

Some kinds of native building stone, which have been made to answer, have not turned out very well in the end. As an illustration, I might refer to the old (now defunct) courthouse, which, I think, was built of an argillaceous sandstone which abounds in this neighborhood, and which, in the course of time, decomposed and became so badly abrased by the weather, that notwithstanding all efforts to preserve its appearance by painting and other measures, was disintegrating at a rapid rate, when the fire caused its final destruction.

The Beaver sandstone, which is found on our border, while it is a very good building material for ordinary purposes, such as bridge work, does not commend itself for architectural purposes,

because you cannot produce a very nice effect by it. A few houses on Penn Street have their fronts built of this stone, but they do not strike me as very attractive.

There is one kind of stone in this country which is not alluded to in Captain Hunt's paper, and which has never received the attention it really deserves, on account of its very superior quality, but which is gradually coming into notice, and that is the oolitic limestone of central Indiana. It is a very compact and perfectly durable, almost indestructible, building material, not only for rough purposes, but it also admits of a very high polish. It is used extensively now in the neighborhood, where it appears for ornamental purposes, tombstones, monuments, etc. The new soldiers' monument in Indianapolis is being built of it. We have been using it very freely for bridge work, and it has no superior, to my knowledge, anywhere, unless you go into the very expensive kinds of granites and marbles.

The oolitic limestone of Indiana belongs to the sub-carboniferous group, and to that particular formation known in the Geological Reports of the Western States as the "Saint Louis Limestone" or "Cave Limestone."

It occurs in a massive ledge, varying from 30 to 70 feet in thickness, free from the stratified partings which characterize other limestone, and may be quarried in blocks of any size or form required, limited only by the capacity of the appliances for handling and transportation.

It possesses great strength and elasticity, works freely, both by hand and machinery, carves to clean, sharp lines, and is susceptible of a high polish. It is a nearly pure carbonate of lime (95 to 98 per cent.), free from perishable ingredients, and consequently indestructible by ordinary atmospheric influences.

Owing to these properties it is rapidly gaining favor in the leading markets, and the demand for it is steadily increasing.

This formation extends from the Ohio River in Harrison county, Indiana, northwesterly to the Illinois State line, but does not attain important development north of Owen county.

It is worked at points on the I. & V. R.R. between Gosport and Spencer, and also at Stinesville, Ellettsville, and Bloomington,

in Monroe County, Bedford and vicinity in Lawrence county, and Salem in Washington county.

The belt of surface in which the stone outcrops is about 8 miles wide in Owen county, 10 miles in Monroe, and widens out to about 16 miles in Lawrence county.

In the latter county the valleys of all the larger creeks have been cut through the limestone formation, leaving the rock exposed on the hillsides, and presenting many points for successful quarry work. This is particularly true of the valleys of Salt Creek and of Leatherwood Creek.

When sawed, its modulus of rupture is 2338; compression, 12,675; elasticity, 4,889,480. When tool dressed, its modulus of rupture is 1477; compression, 7857; elasticity, 2,679,475. These figures are taken from a series of experiments made by Mr. Th. H. Johnson, member of this Society, and published in the Annual Report of the State Geologist of Indiana for the year 1881.

This stone was mentioned at one time as a possible material to be used for the completion of that edifice which Uncle Sam has been building during the last fifteen years here in Pittsburg.

A Member: What is the cost?

M. J. Becker: It can be delivered in the rough, of suitable sizes to be used for bridge work, for instance, for about 15 or 16 cents per cubic foot. It can be delivered, sawed on the top and bottom, for about 20 cents; and sawed on all sides for about 20 or 28 cents; these prices are for the stone delivered at Indianapolis.

Mr. Hoag: That is for the better quality. They have two or three qualities besides.

M. J. Becker: I refer to what is called the Bedford limestone.

I. M. Hoag: At the Bedford quarries they have two or three colors; two shades in one stone. Their inferior stone they sell at 8 or 10 cents, and then the better quality at 25 to 28 cents.

M. J. Becker: I do not think the color has anything to do with the quality; it merely affects the appearance. Of course the outcroppings may not be so good in color, but when you get into the interior this defect disappears.

Mr. Schneider: There is one point not yet mentioned in this

discussion. It seems to have been overlooked, and that is the power of the various building materials to resist extreme heat. All cities are subject to great conflagrations, and it seems to me it is very important to understand how any building material will act under such exposure.

M. J. BECKER: I would like to ask Mr. Schneider if he ever built an ash-pit on a railroad of any kind of stone that stood.

MR. SCHNEIDER: I have built a great many that did not last; but this is the point: If a building will resist extreme heat for an hour, or two hours, it may be saved. We do not expect a building to resist heat forever, but a few hours might save it.

W. L. SCAIFE: I might say in answer to Mr. Schneider's question that I visited Boston after the great fire with the idea of seeing how the so-called fire-proof buildings had stood the test there. I wandered all over the burnt district, and found that granite was not good to resist heat at all. Nearly all the granite buildings had been affected by the intense heat, and had crumbled to a kind of mortar, especially where water had been thrown on them. Brick stood very well, in most cases not seeming to have been affected at all. One fact, however, was impressed on my mind, that granite as a fire-proof material is very undesirable.

A MEMBER: I think that was also shown in a good many instances in the Chicago fire. Granite fronts would burst when exposed to heat, when the fire was on the other side of the street.

J. A. BRASHEAR: In connection with this, although not directly bearing upon the matter of building stones, I would like to ask what is the general method of cutting up and quarrying stone? I ask the question from the fact of having had a chat lately with some gentlemen of our city who are producing what they call a "crushed steel," to be used in connection with stone cutting. They tell me that it is becoming largely used in the eastern quarries, and it expedites the work very much. They report that it expedites the work at least 33 per cent. I examined quite an amount of the crushed steel under a microscope. They have what they call a "crushed steel" and a "crushed steel emery." What they call "crushed steel" I examined under the microscope. Most of the grains were sharply angular, and were either of a blue tint or

straw color; but few grains in the whole mass were of the gray-white color of "glass" hand steel itself. But when I examined the "crushed emery steel," I could not see any colored grains, except an isolated one here and there. We have not yet tried any of it in the processes of cutting glass, but propose to do so at an early date. The manufacturers claim that they depend upon the sharp angular corners of the grains to do the cutting, and claim it will last much longer than emery, for ordinarily as long as there are any grains not broken down or worn out they keep on cutting. Emery seems to break down and quit cutting in a short time; so does corundum. I should think it would be interesting to see this tried on building materials. In the matter of the size of these grains I saw particles as fine as No. 150 emery, and from that they ran up to nearly ⅛ inch, and the particles or grains were quite uniform. In the abrading material known as the Tilghman-shot, which is made of chilled iron, I found nearly twenty different sizes, all sold as one number, but in this crushed steel there were not more than two or three sizes.

WM. METCALF: I am very largely interested in that crushed steel. We are trying to make some dies for these people that will crush the confounded stuff. As I understand the process, they put high carbon steel, such as old files and material of that kind, to a very great heat,—what we would call over-heating for any ordinary purpose,—then they quench this steel in water so as to cause it to become excessively hard and brittle; then the pieces are put in a little stamp-mill and stamped. Afterwards the pieces so broken are, I suppose, sifted, and I think the uniformity of which you speak is probably due to passing through uniform sieves, making the variety of sizes uniform.

I am informed that this steel is not only cheaper than emery, but vastly quicker and does handsomer work, that it makes a finer polish, and puts it on quicker and better in every way than emery. As to these larger pieces, if the steel was not pounded very much, it would show such a variety of color as you mention, because the steel would crack in the water, and the surfaces would oxidize to the different colors.

J. A. BRASHEAR: We generally use No. 50 shot for the abrad-

ing of surfaces, and it does it in a very few minutes, but emery is soon transformed into slush; this shot cuts as long as it stays on the wheel. It has the drawback,—not a very expensive one,—that when the coarse material is used on an iron wheel it can never be used for any fine work afterwards. The coarser particles seem to embed themselves into the iron wheel, and you must use one wheel for coarse work and another for fine work.

There being no further discussion the Society adjourned.

S. M. WICKERSHAM,
Secretary.

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W. L. Scaife.

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LIST OF MEMBERS.

Date of Membership.		
May 21, '80.	Aiken, Henry,	Homestead, Pa.
Jan. 6, '80.	Ackenbeil, Chas.,	Chief Eng. B. & O. R. R., Elizabeth, N. J.
Mar. 20, '88.	Aikman, Edw. G.,	150 Broadway (Room 95), New York.
Oct. 20, '85.	Albree, C. B.,	18 Market St., Pittsburg, Pa.
Apr. 20, '80.	Amsler, Chas., M.E.,	Bissel Block, Pittsburg, Pa.
Dec. 16, '84.	Anderson, J. W.,	45 Fremont St., Allegheny, Pa.
Jan. 6, '80.	Armstrong, Edw.,	Supt. Alleg. Water Works, 160 Webster Ave., Allegheny, Pa.
Jan. 6, '80.	Armstrong, H. W.,	Metcalf, Paul & Co., Pittsburg, Pa.
Jan. 18, '87.	Arms, W. F., M. E.,	R. & P. C. & I. Co., Punxsutawney, Pa.
Nov. 20, '88.	Arras, John W.,	P. O. Box 485, Pittsburg, Pa.
Apr. 15, '90.	Ashworth, Daniel,	Hamilton Building, Pittsburg, Pa.
Feb. 21, '82.	Aull, W. F., C. E.,	Manager Denny Estate, Box 91, Pittsburg, Pa.
Jan. 6, '80.	Awl, John L.,	Mgr. Monong. Incline Plane, Pittsburg, Pa.
Sept. 20, '87.	Bailey, Chas.,	Wilkinsburg, Pa.
Sept. 16, '84.	Bailey, Jas. M.,	Mfr. Sligo Iron Works, Pittsburg, Pa.
Jan. 15, '84.	Baker, Chas. H.,	Metcalf, Paul & Co., Verona, Pa.

Date of Membership.		
May 18, '84.	Bakewell, Thos. W.,	Bakewell Building, Pittsburg, Pa.
June 19, '88.	Bakewell, Wm.,	110 Diamond St., Pittsburg, Pa.
Apr. 17, '88.	Barbour, Geo. H.,	20 Portland Block, Chicago, Ill.
Feb. 17, '80.	Barret, Jonathan,	Hamilton Building, Pittsburg, Pa.
May 19, '85.	Barnes, Phineas,	Jones & Laughlins, Ltd., Pittsburg, Pa.
Nov. 21, '82.	Bates, Onward,	C. Eng., C. M. & St. P. R. R. Milwaukee, Wis.
Jan. 6, '80.	Becker, Max. J.,	C. Eng., P., C. & St. L. Ry., Pittsburg, Pa.
Jan. 20, '85.	Beckfield, Chas.,	804 Duquesne Way, Pittsburg, Pa.
Nov. 19, '89.	Bell, W. G.,	P. O. Box 976, Pittsburg, Pa.
Jan. 19, '86.	Bennett, C. M.,	Supt.Eng.C.,St.L.&P.R.R., Richmond, Ind.
Dec. 18, '83.	Benney, Jas.,	Emsworth, Pa.
Jan. 6, '80.	Bigelow, E. M.,	Chf. of Dept. of Public Wks., Pittsburg, Pa.
Feb. 19, '89.	Billen, C. E.,	Pencoyd Bridge Cons. Co., 261 S. 4th St., Phila., Pa.
Mar. 18, '91.	Black, S. W.,	99 4th Ave., Pittsburg, Pa.
Mar. 21, '82.	Blake, F. C.,	Penna. Lead Works, Mansfield Valley, Pa.
Sept. 18, '83.	Blank, Hugo,	Chemist, 77 4th Ave., Pittsburg, Pa.
Jan. 11, '89.	Blaxter, G. H.,	Allegheny Co. Light Co., Pittsburg, Pa.
Mar. 18, '84.	Bole, W. A.,	Supt. Westinghouse Mach. Co. 25th and Liberty Sts., Pittsburg, Pa.

Date of Membership.		
Jan. 6, '80.	Borntraeger, H. W.,	Keystone Bridge Co., Pittsburg, Pa.
Apr. 15, '90.	Bothfield, Charles,	Bridge and Iron Works, Detroit, Mich.
Apr. 19, '81.	Boyd, Henry A.,	National Tube Works, McKeesport, Pa.
Mar. 18, '84.	Brashear, John A.,	Optician, Observatory Ave., Allegheny, Pa.
Nov. 16, '80.	Bray, Thos. I.,	Warren, O.
Apr. 19, '87.	Breen, H.,	Keystone Bridge Co., Pittsburg, Pa.
Jan. 6, '80.	Brendlinger, P. F.,	C. E. Schuylkill Valley R. R. R. Co., Pottsville, Va.
Jan. 19, '86.	Brockett, Alonzo H.,	Mellor & Hoene, Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Browne, Geo. H.,	Supt. Water Works, Pittsburg, Pa.
Jan. 6, '80.	Brown, W. R.,	City Engineer's Office, Pittsburg, Pa.
Apr. 18, '82.	Brunot, H. J.,	Greensburg, Pa.
Jan. 16, '83.	Buchanan, C. P., Jr.,	P., C. & St. L. R. R., Pittsburg, Pa.
Feb. 9, '86.	Buel, A. W.,	Care of Chf. Eng. Mich. Cen. R. R.
Jan. 18, '87.	Buente, C. F.,	Stone Contractor, Duquesne Way & 10th St., Pittsburg, Pa.
Jan. 6, '80.	Bullock, W. S.,	Taylor & Bullock, Pittsburg, Pa.
Sept. 21, '80.	Burgher, Rutherford,	W. P. R. R., Springdale, Pa.
Jan. 6, '80.	Butz, E. M.,	Architect, 132 1st Ave., Pittsburg, Pa.
Jan. 19, '86.	Cadman, A. W.,	Brass Manufacturer, Pittsburg, Pa.
Feb. 9, '86.	Campbell, Harry C.,	Nat. Gas Burners, 6 Ninth St., Pittsburg, Pa.

Date of Membership.		
Dec. 20, '87.	Campbell, Hugh C.,	Duquesne Forge, Rankin Station, Pa.
May 23, '82.	Camp, Jas. M.,	Tarentum, Pa.
Feb. 20, '83.	Carhart, Danl.,	C. E., Prof. Math. and Eng., Western University, Allegheny, Pa.
May 19, '85.	Carlin, Thos. H.,	Machinist, 186 Lacock St., Allegheny, Pa.
Nov. 18, '84.	Carlin, David,	Mgr. W. G. Price & Co. Iron and Lead Works, 5th Ave. and Price St., Pittsburg, Pa.
Apr. 20, '80.	Carnegie, Andrew,	Steel, 55 Broadway, New York.
Mar. 18, '91.	Caughey, E. G.,	15 North Ave., Allegheny, Pa.
Sept. 18, '83.	Chambers, J. S., Jr.,	C. E., Box 212, Trenton, N. J.
Feb. 17, '80.	Chess, H. B.,	Chess, Cook & Co., Nails and Tacks, Pittsburg, Pa.
Nov. 21, '82.	Clapp, Geo. H.,	Chemist, 95 and 97 Fifth Ave., Pittsburg, Pa.
May 19, '89.	Clark, Louis J.,	Western Pa. Phonograph Co., 146 Fifth Ave., Pittsburg, Pa.
Jan. 18, '88.	Clark, R. N.,*	Rustless Iron Co., 32d and Smallman Streets, Pittsburg, Pa.
Oct. 16, '83.	Coffin, Wm.,	Draughtsman, Franklin St., Allegheny, Pa.
Apr. 19, '87.	Colby, J. A.,	Penn Building, Pittsburg. Pa.
Sept. 18, '89.	Colon, Thos. F.,	Western and Grant Aves., Allegheny, Pa.
Feb. 22, '81.	Cooper, Chas. A.,	Bakewell Building, Pittsburg, Pa.
Dec. 20, '81.	Cooper, John W.,	Draughtsman, Pitts. Locomotive Works, Allegheny, Pa.

Date of Membership.		
Nov. 19, '89.	Cornelius, W. A.,	Hazlewood, B. & O. R. R., Pittsburg, Pa.
Apr. 15, '84.	Cueto, Jose de,	Union Bridge Co., Athens, Pa.
Sept. 21, '80.	Curry, H. M.,	Lucy Furnace Co., Pittsburg, Pa.
June 19, '88.	Cunningham, A. C.,	G. W. G. Ferris & Co., Hamilton Building, Pittsburg, Pa.
May 23, '83.	Danse, L. O.,	Architect, Helena, Montana.
June 19, '88.	Davis, Chas. H.,	1026 Pine Street, Philadelphia, Pa.
Jan. 6, '80.	Davis, Chas.,	County Eng., Court House, Pittsburg, Pa.
Dec. 21, '80.	Davidson, Geo. S.,	McCance Building, Pittsburg, Pa.
Jan. 6, '80.	Dempster, Alex.,	C. E., Coal Operator, Stevenson Building, Pittsburg, Pa.
Mar. 18, '84.	Dickson, Thos. H.,	P. O. Box 672, Pittsburg, Pa.
Jan. 6, '80.	Diescher, Samuel,	M. E., Hamilton Building, Pittsburg, Pa.
Apr. 19, '81.	Dixon, C. G.,	Contractor, 34 Park Way, Allegheny, Pa.
Nov. 15, '87.	Dobson, Thos. H.,	Engineer, W. P. R. R., Shadyside P. R. R., Pa.
Apr. 15, '84.	Dravo, H. G.,	Iron Mcht., 413 Wood St., Pittsburg, Pa.
Jan. 18, '88.	DuBarry, H. B.,	Office Ch. Eng. Pa. Lines, Pittsburg, Pa.
Jan. 22, '89.	DuPuy, H. P.,	Westinghouse Building, Pittsburg, Pa.
Jan. 18, '81.	Eckert, E. W.,	C. E., Room 224 Aldrich Ct. Bldg., No. 45 Broadway, New York.

Date of Membership.		
Jan. 6, '80.	Edeburn, W. A.,	Eng. and Surveyor, Bakewell Building, Pittsburg, Pa.
Mar. 18, '91.	Edwards, J. P.,	Uniontown, Pa.
Jan. 6, '80.	Ehlers, Chas.,	City Eng., No. 8 City Hall, Allegheny, Pa.
Feb. 27, '88.	Engle, Geo. W.,	Eng. Gen. Office Penna. Co., Pittsburg, Pa.
Sept. 19, '82.	Engstrom, F.,	Engineer, Penna. Co., Pittsburg, Pa.
Feb. 4, '88.	Estrade, E. D.,	Engineer, Chief Eng. Office, P., C. & St. L. Ry., Pittsburg, Pa.
Nov. 15, '87.	Euwer, A. H.,	Lumber Merchant, Allegheny, Pa.
Dec. 20, '87.	Felkel, Frank,	335 Main St., Lawrenceville, Pittsburg, Pa.
Mar. 6, '86.	Ferris, Geo. W. G.,	C. E., Insp. of Iron and Steel, P. O. Box 539, Pittsburg, Pa.
Apr. 19, '87.	Fielding, J. S., C. E.,	Care of Jas. Inglis, 17 Oxford St., Rochester, N. Y.
June 16, '85.	Fisher, S. B.,	Engineer, Green Bay, Wis.
Jan. 20, '85.	Fitler, F. K.,	121 Water St., Pittsburg, Pa.
Apr. 16, '89.	Fleming, H. S.,	Cameron Iron and Coal Co., Emporium, Pa.
Jan. 18, '87.	Follansbee, Gilbert,	Supt. Chamber of Commerce, Pittsburg, Pa.
Sept. 22, '87.	Fortune, W. W.,	Engineer, Turtle Creek, Pa,
Feb. 21, '82.	Frank, Isaac W.,	Founder, Lewis Foundry Co.. Pittsburg, Pa.
Jan. 6, '80.	Frost, A. E.,	Prof. of Physics, W. U., Perryville Ave., Allegheny, Pa.
Apr. 17, '88.	Fulton, Louis B.,	Chancery Lane, Pittsburg, Pa.

Date of Membership.		
Jan. 19, '86.	Geisenheimer, W. A.,	608 Fifth Ave., Pittsburg, Pa.
Apr. 15, '90.	Giles, W. A.,	Schmidt Bldg., Pittsburg, Pa.
Oct. 16, '83.	Glafey, Frederick,	Keystone Bridge Works, Pittsburg, Pa.
Feb. 17, '80.	Goodyear, S. W.,	, Waterbury, Conn.
Jan. 21, '90.	Goodwin, J. M.,	Sharpsville, Mercer Co., Pa.
Jan. 6, '80.	Gottleib, A.,	Room 75, Major's Block, Chicago, Ill.
June 16, '85.	Grant, Horace E.,	119 First Ave., Pittsburg, Pa.
Apr. 20, '86.	Gray, W. C.,	Gray's Iron Line, Pittsburg, Pa.
Apr. 21, '85.	Griffen, A. L.,	Keystone Bridge Co., Pittsburg, Pa.
May 19, '85.	Grimes, J. B., M.D.,	327 Carson St., Pittsburg, Pa.
Sept. 19, '82.	Gwinner, Fred., Jr.,	Contractor, Allegheny, Pa.
Mar. 20, '83.	Hackett, Geo. W.,	Cement, Lime and Terra Cotta, 1009 Library St., Pittsburg, Pa.
June 15, '86.	Halstead, J. C.,	C. E., Insp. of Iron and Steel, G. W. G. Ferris & Co., Hamilton Building, Pittsburg, Pa.
Oct. 15, '89.	Handy, J. O.,	95 Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Harlow, Jas. H.,	Hydraulic Engineer, 411 Wood St., Pittsburg, Pa.
Apr. 19, '81.	Harlow, Geo. R.,	Hydraulic Engineer, 441 Wood St., Pittsburg, Pa.
Dec. 16, '84.	Hay, Saml. W.,	512 Hamilton Building, Pittsburg, Pa.
Jan. 6, '80.	Hemphill, Jas.,	Machinist, Mackintosh, Hemphill & Co., Pittsburg, Pa.
Nov. 14, '85.	Heron, Fred.,	Supt. Phœnix Iron Works, Phœnixville, Pa.

Date of Membership.		
Jan. 19, '86.	Hetzel, Jas.,	Box 346, Canton, O.
Apr. 19, '87.	Hibbard, H. D.,	Hainsworth Steel Co., Pittsburg, Pa.
Nov. 20, '88.	Hoag, I. V. Jr.,	43 Sixth Ave., Pittsburg, Pa.
Apr. 20, '80.	Hoffstot, Frank N.,	Iron Broker, Water St., Pittsburg, Pa.
Sept. 18, '88.	Hohl, L. I.,	Ruth St., 32d Ward, Pittsburg, Pa.
Dec. 18, '88.	Holland, W. J.,	Fifth Ave., Oakland, Pittsburg, Pa.
Nov. 15, '87.	Hopke, T. M.,	Linden Steel Co., Pittsburg, Pa.
Oct. 16, '88.	Howe, H. M.,	241 Beacon St., Boston, Mass.
Oct. 18, '81.	Hunt, A. E.,	Chemist, Schmidt & Friday Bldg., Pittsburg, Pa.
Jan. 22, '89.	Hunt, H. E.,	Emerson St., E.E., Pittsburg, Pa.
Mar. 17, '85.	Hunter, Jas.,	323 Carson St., S.S., Pittsburg, Pa.
Oct. 18, '87.	Hyde, C.,	Eng., Room 23, Lewis Block, Pittsburg, Pa.
Mar. 18, '80.	Jarboe, W. S.,	14 Garfield Ave., Allegheny, Pa.
Dec. 18, '88.	Jenkins, J. B.,	98 Arch St., Allegheny, Pa.
Feb. 22, '81.	Jennings, B. F.,	Preble Ave., Allegheny, Pa.
Jan. 18, '88.	Johnson, Thos. H.,	Penna. Lines, Tenth and Penn Sts., Pittsburg, Pa.
Apr. 19, '81.	Jones, B. F.,	Iron Manufacturer, Pittsburg, Pa.
Mar. 20, '88.	Jones, W. Larimer,	Jones & Laughlins, Ltd., Pittsburg, Pa.
Nov. 16, '80.	Kaufman, Gustave,	814 Hamilton Building, Pittsburg, Pa.

Date of Membership.		
May 18, '80.	Kay, J. C.,	Machinery, Kay Bros. & Co. Water St., Pittsburg, Pa.
Feb. 17, '85.	Kay, Jas. I.,	Patent Attorney, 96 Diamond St., Pittsburg, Pa.
June 19, '88.	Keating, A. J.,	Iron Mfr., Zug & Co., Pittsburg, Pa.
May 21, '89.	Keenan, J. J.,	Holidaysburg, Blair Co., Pa.
Mar. 17, '85.	Kelly, J. A.,	28th and Smallman Sts., Pittsburg, Pa.
Jan. 16, '85.	Kelly, J. W.,	Road Master P. & W. Ry. Youngstown, O.
May 18, '86.	Kennedy, Julien,	48 Fifth Ave., Pittsburg. Pa.
Sept. 19, '82.	Kenyon, L. H.,	Pitts. Locomotive Works, Allegheny, Pa.
June 19, '88.	Kenyon, Edw. H.,	G. W. G. Ferris & Co., Hamillton Building, Pittsburg, Pa.
Mar. 19, '89.	Kerr, A. C.,	Third Ave., Pittsburg, Pa.
Mar. 18, '91.	Kerr, C. V.,	42 Clifton Park, Allegheny, Pa.
May 15, '88.	Kettredge, G. W.,	Engineer, M. of Way, Pittsburg, Pa.
June 19, '88.	Kimball, Frank I.,	Mining Engineer, Greensburg, Pa.
Feb. 21, '82.	King, T. M.,	B. & O. R. R., Baltimore, Md.
Mar. 16, '82.	Kirk, Arthur,	Arthur Kirk & Son, Powder and High Explosives, 910 Duquesne Way, Pittsburg, Pa.
Nov. 15, '87.	Kirkland, A. P.,	Supt. W. P. R. R., Allegheny, Pa.
Apr. 19, '87.	Klages, Geo. W.,	Machinist, Foreman, 130 Eleventh St., S.S., Pittsburg, Pa.

Date of Membership.		
Apr. 19, '87.	Koch, Walter E.,	Supt. Spang's Steel Works, Sharpsburg, Pa.
Jan. 6, '80.	Laing, Geo.,	1004 Penn Ave., Pittsburg, Pa.
Nov. 20, '88.	Langley, J. W.,	136 First Ave., Pittsburg, Pa.
May 19, '85.	Lauder, Geo.,	48 Fifth Ave., Pittsburg, Pa.
June 19, '88.	Lean, D. R.,	Lean & Blair, Engineers and Contractors, Pittsburg, Pa.
Jan. 17, '88.	Leech, Louis D.,	44th St. and Centre Ave., Pittsburg, Pa.
Apr. 15, '84.	Leishman, John A. G.,	Lewis Block, Pittsburg, Pa.
May 16, '80.	Leschorn, Alex.,	M. E., Phœnix Bridge Co., Phœnixville, Pa.
Mar. 16, '80.	Lewis, J. L.,	Lewis Foundry and Machine Co., Ltd., Pittsburg, Pa.
Apr. 20, '80.	Lewis, W. J.,	Linden Steel Co., Pittsburg, Pa.
Feb. 21, '82.	Lindenthal, Gustave,	Engineer, Lewis Block, Pittsburg, Pa.
Oct. 16, '88.	Linkenheimer, A. E.,	141 Federal St., Allegheny.
Sept. 16, '84.	Lloyd, Henry,	Iron Mfr., H. Lloyd, Sons & Co., Pittsburg, Pa.
May 19, '81.	Lloyd, John W.,	Iron Mfr., H. Lloyd, Sons & Co., Pittsburg, Pa.
Oct. 19, '80.	Loomis, Geo. P.,	Iron Mfr., Crescent Steel Works, Pittsburg, Pa.
Jan. 6, '80.	Lowry, Jos. L.,	Hydraulic Eng., City Hall, Pittsburg, Pa.
Jan. 6, '80.	Macbeth, Geo. A.,	Keystone Flint Glass Co., Pittsburg, Pa.
Apr. 19, '81.	Malone, M. L.,	Engineer, 320 Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Martin, Wm.,	Resident Eng., Davis Island Dam, P. O. Box 70, Pittsburg, Pa.

Date of Membership.		
Dec. 18, '83.	Mead, Edwd.,	P. O. Box 124, Louisville, Ky.
Jan. 6, '80.	Melber, Fred.,	P. O. Box 155, Sharpsburg, Pa.
June 18, '89.	Mellor, Walter E.,	77 Fifth Ave., Pittsburg, Pa.
Mar. 20, '88.	Meredith, John R.,	60 Seventh St., Pittsburg, Pa.
Mar. 20, '88.	Mesta, Geo.,	C. E., Vice Pres. Leechburg Foundry and Machine Co., 130 First Ave., Pittsburg, Pa.
Jan. 6, '80.	Metcalf, Wm.,	Crescent Steel Works, 49th and R. R. Sts., Pittsburg, Pa.
Jan. 15, '84.	Meyran, L. A.,	Canonsburg Iron and Steel Co., Germania Bank Bldg., Pittsburg, Pa.
Sept. 18, '83.	Miles, Geo. K.,	Sec. and Treas. Charlotte Fur Co., Pittsburg, Pa.
Feb. 21, '82.	Milholland, J. B.,	Engine Builder, Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Miller, Reuben,	Crescent Steel Works, Pittsburg, Pa.
May 19, '85.	Miller, Wilson,	Sec. Pittsburg Loco. Works, 18 Lincoln Ave., Allegheny, Pa.
Oct. 19, '80.	Milliken, A. C.,	Pottsville Iron and Steel Co., Pottsville, Pa.
Apr. 19, '81.	Moorhead, M. K.,	Moorhead-McCleane Co., Pittsburg, Pa.
Mar. 15, '81.	Morgan, Jas.,	2204 Carson St., Pittsburg, Pa.
Apr. 15, '90.	Morgan, Wm.,	2 Sixth St., Pittsburg, Pa.
Oct. 19, '86.	Morris, G. W.,	P. O. Box 56, Pittsburg, Pa.
Jan. 21, '90.	Morris, H. Saunders,	Westinghouse Electric Co., Pittsburg, Pa.

Date of Membership.		
May 15, '83.	Morse, H. C.,	Engineer, Edgemoor, Del.
Mar. 18, '91.	Mueller, Gustave,	Duquesne, Pa.
Dec. 19, '89.	Müller, C. F.,	606 Penn Building, Pittsburg, Pa.
Apr. 15, '80.	Munro, R.,	Boiler Manufacturer, 23d and Smallman Sts., Pittsburg, Pa.
Mar. 16, '80.	McCandless, E. V.,	Merchant, Pittsburg, Pa.
May 19, '85.	McConnell, John A.,	69 Water St., Pittsburg, Pa.
Mar. 15, '81.	McCulley, R. L.,	101 Fifth Ave., Pittsburg, Pa.
Feb. 22, '81.	McCune, John D.,	98 Fourth Ave., Pittsburg, Pa.
May 21, '89.	McDonald, John,	239 Forty-fourth St., Pittsburg, Pa.
Dec. 17, '89.	McDonald, C. J.,	314 Penn Building, Pittsburg, Pa.
Apr. 18, '87.	McDowell, Jas.,	Optician, Observatory Ave., Allegheny, Pa.
Mar. 19, '89.	McKean, R. A.,	812 Hamilton Building, Pittsburg, Pa.
Sept. 21, '80.	McKinney, J. P.,	60 Sheffield St., Allegheny, Pa.
Jan. 16, '83.	McKinney, R. M.,	Elizabeth, Pa.
Mar. 15, '81.	McLennan, Alex.,	56 Second Ave., Pittsburg, Pa.
Feb. 21, '82.	McMurtry, Geo. G.,	Pittsburg, Pa.
Feb. 17, '85.	McQuiston, Jas.,	26th and Railroad Sts., Pittsburg, Pa.
Mar. 15, '81.	McRoberts, J. H.,	400 Grant St., Pittsburg, Pa.
Apr. 15, '84.	McTighe, Jas. J.,	175 W. Carson St., S. S., Pittsburg, Pa.
Jan. 6, '80.	Naegeley, Jno.,	Eng. and Architect, Room 9, Renshaw Bldg., Liberty & 9th Sts., Pittsburg, Pa.
Jan. 19, '86.	Nevins, Richard, Jr.,	Seattle, Washington.
	Nichols, T. R.,	223 Allegheny Ave., Allegheny, Pa.

Date of Membership.		
Apr. 20, '80.	Nimick, F. B.,	Steel Mfr., Singer, Nimick & Co., Pittsburg, Pa.
Feb. 21, 82.	Noble, Patrick,	Pacific R. M. Co., 202 Market St., San Francisco, Cal.
May 19, '85.	Osborn, Frank C.,	King Iron Bridge and Mfg. Co., Cleveland, O.
Feb. 20, '83.	Paddock, Jos. H.,	Civil Engineer, Connellsville, Pa.
May 21, '89.	Paine, G. H.,	Swissvale, Pa.
Mar. 18, '84.	Painter, Park,	Iron Mfr., J: Painter & Sons, Pittsburg, Pa.
Nov. 20, '88.	Palmer, W..P.,	37 Beach St., Allegheny, Pa.
Sept. 18, '88.	Park, J. G.,	Americus, Georgia.
Jan. 6, '80.	Parkin, Chas.,	Parnassus, Pa.
Apr. 15, '84.	Parkin, Walter F.,	136 First Ave., Pittsburg, Pa.
Feb. 22, '81.	Patterson, Peter,	National Tube Works, McKeesport, Pa.
Nov. 15, '81.	Paul, J. W.,	Verona Tool Works, Seventh Ave. and Liberty St., Pittsburg, Pa.
Apr. 15, '84.	Paulson, Frank G.,	Hatter, Wood St., Pittsburg, Pa.
Mar. 15, '87.	Pease, Chas. T.,	Westinghouse Electric Co., Pittsburg, Pa.
Sept. 18, '83.	Peebles, Andrew,	Architect, Schmidt & Friday Building, Pittsburg, Pa.
Jan. 6, '81.	Pettit, Robt. E.,	Penna. R. R. Co., Altoona, Pa.
Nov. 20, '88.	Petitdidier, Lewis M.,	Fifteenth and Arapahoe Sts., Denver, Col.
Jan. 20, '80.	Phillips, F. C.,	Prof. of Chemistry, 59 Sherman Ave., Allegheny, Pa.
Jan. 16, '83.	Phipps, Henry, Jr.,	Carnegie, Phipps & Co., Ltd., Pittsburg, Pa.

Date of Membership.		
Dec. 20, '81.	Porter, John C.,	Spang Steel and Iron Co., Pittsburg, Pa.
May 17, '87.	Porter, John E.,	Iron Broker, 413 Wood St., Pittsburg, Pa.
Jan. 16, '83.	Prentice, W. J.,	Cement, Lime & Terra Cotta, 1009 Liberty St., Pittsburg, Pa.
Apr. 17, '83.	Price, C. B.,	A. V. R. R., Pittsburg, Pa.
Dec. 18, '88.	Purves, Jas.,	Munhall, Pa.
Jan. 6, '80.	Quincy, W. C.,	Mon. Cen. R. R., 3d Ave. and Fry St., Pittsburg, Pa.
Mar. 15, '81.	Ramsey, Jos., Jr.,	Asst. V.-Pres. C. C. C. I. & St.L. Ry., Cincinnati, Ohio.
Jan. 20, '80.	Reed, Jas.,	Supt. Schuylkill Div. P.R.R., Reading, Pa.
Jan. 20, '80.	Rees, Thos. M.,	Machinist, J. Rees & Sons, Pittsburg, Pa.
Jan. 6, '80.	Reese, Jacob,	400 Chestnut St., Philadelphia, Pa.
June 19, '88.	Reinmann, A. L.,	Westinghouse Electric Co., Pittsburg, Pa.
Jan. 20, '85.	Reisinger, Chas.,	Sewickley, Pa.
May 15, '83.	Reno, Geo. E.,	90 Fourth Ave., Pittsburg, Pa.
Jan. 9, '80.	Rhodes, Joshua,	Penna. Tube Works, Pittsburg, Pa.
Jan. 6, '80.	Ricketson, John H.,	Founder, 6 Wood St., Pittsburg, Pa.
Apr. 19, '87.	Rider, Percy S.,	6 Ninth St., Pittsburg, Pa.
Apr. 15, '90.	Ritchie, Jas.,	7th Avenue Hotel, Pittsburg, Pa.
Jan. 17, '88.	Robbins, F. L.,	Penn Building, Pittsburg, Pa.
Jan. 7, '80.	Roberts, Thos. P.,	C. Engineer, 53 Beach St., Allegheny, Pa.
Jan. 7, '80.	Rodd, Thos.,	Penna. Co., Pittsburg, Pa.
Nov. 19, '89.	Ruhe, C. H. Williams,	102 Bluff St., Pittsburg, Pa.

Date of Membership.		
Jan. 17, '88.	Ruud, Edwin,	706 Penn Ave., Pittsburg, Pa.
Apr. 15, '84.	Scaife, O. P.,	Wm. B. Scaife & Sons, Structural Iron Works, 119 First Ave., Pittsburg, Pa.
Mar. 20, '83.	Scaife, W. Lucien,	Scaife Foundry and Mach. Co., Twenty-eighth and Smallman Sts., Pittsburg, Pa.
Sept. 20, '87.	Scaife, W. Marcelin,	336 Ridge Ave., Allegheny, Pa.
Apr. 15, '90.	Scheffler, Fred. A.,	Westinghouse Electric Co., Pittsburg, Pa.
Feb. 21, '82.	Schellenberg, F. Z.,	Elysian St., E.E., Pittsburg, Pa.
Jan. 6, '80.	Schinneller, Jacob,	M. E., Room 31, McClintock Block, Pittsburg, Pa.
Feb. 17, '85.	Schmid, Alb.,	Supt. Westinghouse Electric Co., Pittsburg, Pa.
May 15, '83.	Schook, Levi,	1st Ave. and Ferry Streets. Pittsburg, Pa.
Jan. 6, '80.	Schultz, A. L.,	Hiland Ave., E. E., Pittsburg, Pa.
Sept. 19, '82.	Schultz, C. J.,	Iron City Bridge Works, Pittsburg, Pa.
Nov. 15, 81.	Schwartz, F. H.,	5000 Liberty St., Pittsburg, Pa.
Mar. 18, '84.	Schwartz, J. E.,	61 Fourth Ave., Pittsburg, Pa.
Apr. 15, '90.	Scott, Chas. F.,	Westinghouse Electric Co., Pittsburg, Pa.
Jan. 16, '83.	Scovell, Minor,	Engineer and Contractor, Nashville, Tenn.
Jan. 16, '83.	Seaver, J. W.,	79 Fremont St., Allegheny, Pa.
Apr. 19, '87.	Seymour, John E.,	Latrobe, Pa.

Date of Membership.		
Jan. 22, '89.	Shaw, A. G.,	5268 Carnegie St., Pittsburg, Pa.
Jan. 22, '89.	Shaw, W. W.,	County Engineer's Office, Pittsburg, Pa
May 19, '85.	Shelton, Thos.,	National Tube Works, McKeesport, Pa.
Nov. 18, '84.	Shepler, Cassius R.,	Banger & Natchez, S.S., Pittsburg, Pa.
Sept. 19, '82.	Sherzer, W.,	C. Eng., 209 Home Insurance Building, Chicago, Ill.
Nov. 24, '85.	Shultz, O. G.,	McKee's Rocks P. O., Pa.
Dec. 29, '87.	Simpson, Jas. H.,	Carnegie, Phipps & Co., Ltd., Pittsburg, Pa.
Sept. 21, '80.	Singer, Harton G.,	83 Water St., Pittsburg, Pa.
Sept. 21, '80.	Singer, W. H.,	Singer, Nimick & Co., Pittsburg, Pa.
Jan. 6, '80.	Slataper, Felician,	Chief Eng. Penna. Co., Pittsburg, Pa.
Jan. 21, '90.	Smith, F. S.,	Westinghouse Electric Co., Pittsburg, Pa.
Oct. 18, '87.	Smith, John W.,	159 River Ave., Allegheny, Pa.
Feb. 17, '80.	Snyder, Antes,	Eng. Right of Way, P. R. R., Blairsville, Pa.
Apr. 15, '84.	Snyder, W. P.,	Lewis Block, Pittsburg, Pa.
Jan. 18, '88.	Speer, B.,	Prof. of Physics, Pitts. High School, Pittsburg, Pa.
Feb. 17, '80.	Sprague, H. N.,	Porter & Co., Loco. Works, Pittsburg, Pa.
May 19, '81.	Stafford, C. E.,	Shoenberger & Co., Pittsburg, Pa.
May 19, '83.	Stevenson, David A.,	Civil Engineer, Room 6, Union Station, Pittsburg, Pa.
Jan. 19, '86.	Stevenson, W. S.,	Philadelphia Co., Roup St., Pittsburg, Pa.

Date of Membership.		
Nov. 21, '82.	Stewart, Geo. R.,	Gas Engineer, 43 Sixth Ave., Pittsburg, Pa.
Oct. 19, '86.	Stewart, J. H.,	48 Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Stillburg, J. H.,	Architect, 20 Fifth Ave., Pittsburg, Pa.
Jan. 21, '90.	Stillwell, L. B.,	Westinghouse Electric Co., Pittsburg, Pa.
Jan. 6, '80.	Strobel, C. L.,	M. E., 210 Home Insurance Building, Chicago, Ill.
Feb. 17, '91.	Stupakoff, S. H.,	Union Switch and Signal Co., Swissvale, Pa.
Oct. 19, '80.	Sutton, Thos.,	Pittsburg, Pa.
Feb. 20, '83.	Swan, Robert,	Civil Engineer, Allegheny Ave., Allegheny, Pa.
Apr. 19, '87.	Swenson, Emil,	Keystone Bridge Works, Pittsburg, Pa.
Feb. 19, '84.	Taylor, B. H.,	C. E., Rankin Station, Allegheny Co., Pa.
Apr. 20, '80.	Taylor, E. B.,	Genl. Supt. Penna. Co., Pittsburg, Pa.
May 18, '86.	Tener, Geo. E.,	Oliver Bros. & Phillips, New Castle, Pa.
Dec. 21, '81.	Thaw, Wm., Jr.,	Hecla Coke Co., 21 Lincoln Ave., Allegheny, Pa.
Dec. 21, '81.	Thomas, Alex.,	Sewickley, Pa.
Apr. 19, '89.	Thorsell, J. A.,	119 First Ave., Pittsburg, Pa.
Apr. 9, '91.	Tibbitt, C. H.,	68 Sixth Ave., Pittsburg, Pa.
Apr. 21, '85.	Todd, Jas.,	Chemist, 127 North Ave., Allegheny, Pa.
Mar. 18, '91.	Tone, S. L.,	19 Jackson Bldg., Pittsburg, Pa.
Nov. 24, '85.	Totten, Sidney H.,	Pittsburg, Pa.
Dec. 20, '87.	Travelli, Chas. J.,	Chemist, 333 Forty-second St., Pittsburg, Pa.
Jan. 6, '80.	Trimble, Robt.,	Penna. Co., Pittsburg, Pa.
Feb. 22, '81.	Utley, Edwd. H.,	A. V. R. R., Pittsburg, Pa.

Date of Membership.		
May 19, '85.	Verner, M. S.,	Supt. Citizens' Traction Co., 939 Penn Ave., Pittsburg, Pa.
Dec. 20, '87.	Verner, Henry W.,	8 Wood St., Pittsburg, Pa.
Apr. 18, '82.	Wainwright, J.,	C. E., 111 Fourth Ave., Pittsburg, Pa.
Apr. 19, '87.	Wainwright, J. R.,	P. O. Box 264, Pittsburg, Pa.
Jan. 6, '80.	Walker, J. W.,	Forty-seventh St. and A. V. R. R., Pittsburg, Pa.
Oct. 20, '85.	Walker, Arthur,	53 Main St., Zanesville, O.
Jan. 16, '83.	Warden, C. F.,	Greensburg, Pa.
Jan. 6, '80.	Weeks, Jos. D.,	Editor Amer. Manufacturer, Box 1547, Pittsburg, Pa.
Apr. 19, '87.	Weiskopf, Saml. C.,	Box 732, Pittsburg, Pa.
Feb. 21, '82.	Westerman, Thos.,	Verona Tool Works, Verona, Pa.
Feb. 20, '88.	White, H.,	21 Church Ave., Allegheny, Pa.
May 15, '83.	White, T. S.,	Penna. Bridge Works, Beaver Falls, Pa.
Jan. 6, '80.	Whittaker, Lee,	Covington, Ky.
May 18, '80.	Wickersham, S. M.,	C. Eng., Pittsburg, Pa.
Oct. 19, '80.	Wickersham, Thos.,	Mill Mgr., Park Bros. & Co., Pittsburg, Pa.
May 18, '86.	Wierman, Victor,	Eng. Pgh. Div. P. R. R., Pittsburg, Pa.
Jan. 21, '90.	Wigham, Wm.,	Camden, Pa.
Feb. 17, '80.	Wightman, D. A.,	Supt. Pittsburg Loco. Works, Box 76, Allegheny, Pa.
Jan. 6, '80.	Wilcox, John F.,	J. P. Witherow, Lewis Block, Pittsburg, Pa.
May 15, '87.	Wilkins, W. G.,	C. E., 23 Lincoln Ave., Allegheny, Pa.
Feb. 17, '80.	Wilson, Jno. T.,	Penn Bldg., Pittsburg, Pa.
Jan. 19, '86.	Wilson, Howard M.,	Founder, Craig St., Pittsburg, Pa.

Date of Membership.		
Jan. 18, '88.	Wilson, F. T.,	Jersey Shore, Lycoming Co., Pa.
Jan. 18, '88.	Wilson, W. R.,	811 Penn Bldg., Pittsburg, Pa.
Feb. 20, '88.	Winn, Isaac,	National Rolling Mill, McKeesport, Pa.
Jan. 6, '80.	Witherow, J. P.,	Eng. and Contractor, Lewis Block, Pittsburg, Pa.
Nov. 19, '89.	Wolffe, J. J. E.,	Keystone Bridge Co., Pittsburg, Pa.
Jan. 15, '84.	Wood, B. L., Jr.,	Mon. Dredging Co., 43 Sixth Ave., Pittsburg, Pa.
Sept. 21, '80.	Wood, R. G.,	Iron Mills, McKeesport, Pa.
Jan. 18, '88.	Wood, Jos.,	Genl. Supt. Transportation Pa. Lines, Pittsburg, Pa.
Jan. 18, '88.	Woods, Leonard G.,	East End Hotel, Pittsburg, Pa.
Mar. 20, '82.	Yeatman, Morgan E.,	Bridge Engineer, 11 Penna. Ave., Allegheny, Pa.
Jan. 6, '80.	Zimmerman, W. F.,	U. S. Electric Co., Newark, N. J.

CORRESPONDENTS.

Society of Arts,	Boston, Mass.
Massachusetts Institute of Technology, Department of Civil Engineering,	Boston, Mass.
Boston Society of Engineers,	City Hall, Boston, Mass.
Brinsmade, D. S., Sec. Conn. Assoc. of Civil Engineers and Surveyors,	Birmingham, Conn.
State Association of Engineers,	Norwich, Conn.
American Scientific Society,	219 River St., Troy, N. Y.
Sibley College,	Cornell University, Ithaca, N. Y.
American Society of Civil Engineers,	127 E. 23d St., New York.
Amer. Society of Mechanical Engineers,	60 Madison Ave., New York.
American Inst. of Mining Engineers,	Lock Box 223, New York.
Journal of Association of Engineering Societies,	73 Broadway, New York.
Railroad and Engineering Journal,	46 Broadway, New York.
Tichnischer Verein,	210 E. Fifth St., New York.
Engineering News,	Tribune Bldg., N. Y.
University of Illinois,	Champaign, Ill.
Library of Second Geological Survey of Pennsylvania,	907 Walnut St., Philadelphia, Pa.

Franklin Institute,	18 S Seventh St., Philadelphia, Pa.
Engineers' Club of Philadelphia,	1122 Girard St., Philadelphia, Pa.
Tichnischer Verein,	106 Randolph St., Chicago, Ill.
Railway Review,	Chicago, Ill.
American Engineer,	Chicago, Ill.
Western Society of Engineers,	Home Building, Chicago, Ill.
Civil Engineers' Club of Cleveland,	Cleveland, O.
Prof. C. N. Brown, Sec. Ohio Society of S. & C. Engineers,	Columbus, O.
Indiana Soc. of Civil Engineers and Surveyors,	Remington, Ind.
Engineers' Club of St. Louis,	St. Louis, Mo.
Engineers' Club,	Kansas City, Mo.
E. S. Cunningham,	Columbia, Boone Co., Mo.
B. Thompson,	Box 430, Chattanooga, Tenn.
J. M. Whitman, Arkansas Industrial University,	Fayetteville, Ark.
The Practical Mechanic,	Worcester, Mass.
Liverpool Engineering Society,	Colquitt St., Liverpool, England.
Iron and Steel Institute,	Lombard St., London, E. C.
National Association of Builders,	164 Devonshire St., Boston, Mass.
The Technic,	Ann Arbor, Mich.
Stevens Institute of Technology,	Hoboken, N. J.
Engineering and Mining Journal,	27 Park Place, N. Y.
Journal of Society of Arts,	John St., Adelphi, London, W. C.
Institution of C. E.,	25 Great George St., Westminster, London, S.W.

Society of Civil Engineers, Westminster Chambers, London, S.W.

London Patent Office, London, England.

Swedish Societo of C. E., Stockholm, Sweden.

Norsk Tiknisk Tideskrift, Christiana, Norway.

Associadad dos Engenheiros Civis Portuguezos, Lisboa, Portuguezos.

Sociadad Cientifica Argentina, Buenos Aires, S. A.

Club de Engenharia, Rio de Janeiro, Brazil, S. A.

Henry A. Gordon, Inspecting Engineer, Wellington, New Zealand.

Annales des Mines, Paris, France.

E. Ingeniero Civil, 424 Corrientes, Buenos Aires, Argentine Republic, S. A.

Engineering Department, Vanderbilt University, Nashville, Tenn.

T. C. Mendenhall, U. S. Coast Geodetic Survey Office, Washington, D. C.

Amer. Inst. Electrical Engineers, 5 Beekman St., N. Y.

Smithsonian Institution, Washington, D. C.

PROCEEDINGS

OF

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

PITTSBURG, PA.

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OFFICERS FOR 1890.

PRESIDENT,

W. L. SCAIFE.

VICE-PRESIDENTS,

Two Years—PHINEAS BARNES. One Year—A. E. HUNT.

DIRECTORS,

Two Years—R. N. CLARK. Two Years—W. G. WILKINS.

One Year—WILLIAM METCALF. One Year—M. J. BECKER.

SECRETARY,

One Year—S. M. WICKERSHAM.

TREASURER,

One Year—A. E. FROST.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

This Society does not hold itself responsible for the opinions of its members.

TENTH ANNUAL MEETING.

PITTSBURG, JANUARY 21ST, 1890.

SOCIETY met at 8 o'clock P.M., President Brashear in the chair.

Vice-Presidents W. L. Scaife and A. E. Hunt, Director Charles Davis, and 60 members and 4 visitors were present.

The Board presented the names of the following gentlemen, applicants for membership: John M. Goodwin, William Whigham, H. Saunders Morris, L. B. Stillwell, and F. S. Smith, who were balloted for and elected.

The Committee on Union of Societies in the occupancy of one building, presented a printed report, which was distributed.

A. E. Hunt offered the following resolution:

"That the report of the Committee on the union of the various Societies be received, and Resolved, that this Society is ready to join with other Societies in occupying a common home, under suitable conditions, when offered by the Pittsburg Academy of Science and Art," which was adopted.

A. E. Frost presented the following report:

REPORT OF TREASURER

For the Year Ending January 21st, 1890.

RECEIPTS.

1889. January 20.

Balance,					$ 50.24	
Dues from	1	member to	Jan.,	1885,	5.00	
"	3	"	"	1886,	15.00	
"	6	"	"	1887,	30.00	
"	14	"	"	1888,	70.00	
"	41	"	"	1889,	205.00	
"	270	"	"	1890,	1350.00	
"	1	"	"	1891,	2.50	
Total,						$1727.74

EXPENDITURES.

Printing,	$336.50	
Rent of Rooms,	268.00	
Salary of Secretary,	200.00	
Postage and Office Expenses,	154.99	
Insurance,	91.20	
Periodicals,	155.39	
Binding,	66.35	
Stenographer,	50.00	
Book Cases,	57.25	
Commissions on Collections,	53.38	
Blackboard,	14.20	
Total,		$1447.26
Balance in hands of Treasurer,		280.48
		$1727.74

Respectfully submitted,

A. E. FROST,
Treasurer.

The report of S. M. Wickersham, Secretary, was read by J. A. Brashear, viz.:

TENTH ANNUAL REPORT

OF THE

Secretary of the Engineers' Society of Western Pennsylvania.

PITTSBURG, January 21, 1890.

On the 22d January, 1889, the number of names on our list of members was		342
At that meeting were dropped from the roll		13
Leaving on the active list		329
During the year there were admitted		24
Aggregating		353
In the same time we lost by death	3	
" " " by resignation	14	
		17
Leaving on the rolls		336

Ten regular meetings were held and 11 papers were read, viz.:

January 22d. The ninth annual meeting. President Dempster read his retiring address.

February 19th. J. W. Langley read a paper on "International Analysis of Iron and Steel." H. D. Hibbard read a paper on "Electric Welding of Metals."

March 19th. T. H. Johnson read a report from the Committee on Roads, together with the draft of an act for the construction and care of roads, to be presented to the State Legislature for action. J. A. Brashear read a paper on "The Manufacture of Optical Glass."

April 16th. A. E. Hunt read a paper on "The Testing of Metals and Testing Machinery."

May 21st. Louis I. Clark gave a talk on "The Phonograph and Graphophone."

June 18th. Thos. P. Roberts addressed the meeting on the "Johnstown Disaster and South Fork Dam."

October 15th. Isaac S. McGiehan gave a discussion on "Standard Metal Ties."

November 19th. Arthur Kirk read a paper on the "Use of Dynamite in Breaking the Jam at Johnstown."

December 17th. A paper prepared by Alfred E. Hunt on "The Stone Used for Structural purposes in Allegheny County," was read by G. H. Clapp.

The ten meetings were attended by 398 members and visitors, being an average of 39.8 to each. Number of visitors making use of the library was 1067.

S. M. WICKERSHAM,
Secretary.

F. C. Phillips reported for Committee on Library:

JANUARY 22, 1890.

PRESIDENT ENG. SOC. W. PA.:

Sir: The past year has been an uneventful one so far as improvements in the library are concerned.

The number of books added to the collection since the last annual meeting is 67. During the year 1889 the Librarian's

record shows that there were 1067 visitors to the library, an increase of 301 over the number for 1888.

It has been the aim of the committee to have all journals bound as soon as each volume is complete. As is well known the use of the rooms is not confined to members, non-members being permitted to consult the books. We have to report a constantly increasing demand for the literature of electricity and we believe that an urgent demand exists for additional works in this department. A request was made a year ago that members should notify the committee of the names of works relating to special branches of engineering or research, which in their opinion should be in the library. For the benefit of the incoming committee, it is suggested that this request be borne in mind.

Respectfully submitted,
F. C. PHILLIPS,
CHARLES DAVIS,
GEO. S. DAVISON.

The election of officers for the ensuing year being in order, C. H. Davis moved that the Secretary cast a ballot for the ticket recommended by the Nominating Committee at the December meeting, which motion was unanimously adopted. The ballot was cast by B. Spear, Secretary *pro tem*, and the following officers elected:

W. L. Scaife, President, one year; P. Barnes, Vice-President, two years; R. N. Clark, Director, two years; W. G. Wilkins, Director, two years; S. M. Wickersham, Secretary, one year; A. E. Frost, Treasurer, one year; after which J. A. Brashear read the following paper:

THE REFINEMENTS OF MODERN MEASUREMENTS AND MANIPULATIONS.

Progress is to-day written upon every page of the world's record; and particularly in the realms of science is it making its unmistakable mark; from thence extending outward to the vast range of correlated studies that go to make up the sum of

human knowledge and economics. In astronomy and astronomical engineering, in physics and chemistry, in civil and mining engineering, in meteorology and in metrology and in mechanics, to say nothing of many other branches of science, do we find progress as the watchword and the theme that excites and moves the human brain to grander and better achievements. It is my pleasure, and an enjoyable privilege, to call the attention of this Society, in my retiring address as your president, to some of these lines of progress in which I have for many years been interested, and which I trust will prove of interest to you. I shall therefore present some thoughts on the refinements of modern measurements.

When Dr. Alfred M. Mayer, of the Stevens Institute, published his splendid papers on the minute measurements of modern science in the *Scientific American* Supplement, some fifteen years ago, it opened the eyes of many of our American mechanics to the possibilities of a refinement in measurements they had never dreamed of, and I believe those papers, written in such clear and untechnical language, have done an incalculable amount of good to mechanics, who to-day show it by their accurate work, to some of which I shall refer later on.

The day has forever past when we are willing to say or believe that "three barley-corns make one inch," nor is the advanced mechanic of to-day satisfied with his boxwood rule, graduated to thirty-seconds of an inch, save for the coarsest approximate measurements; but he must have his Brown and Sharp standard graduated to one one-hundredth inches for his *coarse* measures, and his micrometer gauges reading to one one-thousandth for his ordinary work. Even in our iron and steel works, the old-time wire gauge, that for a long time held its own, has been displaced by the modern micrometer gauge of infinitely greater accuracy.

My esteemed friend, Mr. George M. Bond, has said very appropriately, that "the arm of King Henry the First, or the barley-corn, though possibly furnishing standards good enough for that time, would hardly satisfy the demands of our modern mechanics or tool-makers, who work very often within the limit of one-thousandth of an inch, and even one-tenth of this apparently mi-

nute quantity, with surprising unconcern and no less accuracy." Prof. Wm. A. Rogers has also shown that many of our modern mechanics can calliper to one thirty-thousandth of an inch. These however are coarse, rough measures when compared with others I shall mention in the course of this paper.

In the domain of astronomical measurements great progress has been made of late years by the use of refined instrumental means, as well as the many methods devised for the elimination of instrumental errors. The divisions of the meridian circle have been brought to astonishing accuracy. I may mention two of the best dividing engines in the world, which I have examined through the courtesy of the constructors. Perhaps the most celebrated is that of the Repsolds in Hamburg. This wonderful engine has come through three generations of celebrated mechanicians, each one adding to its accuracy until now it seems to have reached the limit of human capability; in other words, as perfect as the environments of temperature, and other factors over which human hands and brains have no control, will allow it to be brought. The maximum error of the best circles divided by this engine equals 1.17″. This engine is not automatic, but each line is set by from one to five microscopes, and the division traced by hand.

The other engine is that constructed by Messrs. Fauth & Co., of Washington, D.C., and is entirely automatic in its work. It is a fine piece of mechanical construction, and does honor to the constructors, and when compared with the original dividing engine of Ramsden, which I have examined, and which was a marvellous piece of work for its time, it tells unmistakably the advance of modern mechanical appliances in that direction. The mean error of a circle recently divided on this engine for the Cincinnati Observatory, as determined by Prof. Porter, is not greater than 1.″0. The Heliometer is now playing a most important part in accurate astronomical measurements, and the work of Dr. Elkin of the Yale University Observatory, and that of Dr. Gill at the Cape of Good Hope, with this instrument, will, in all probability, give us a nearer approach to the absolute solar parallax than has yet been obtained; and this may be appreciated when you remember that

the uncertainty lies in the 3d° decimal place of seconds of arc, a quantity altogether inappreciable to ordinary mortals.

This instrument has been largely used in a determination of the parallax of the "fixed" stars, and such measurements are perhaps the most refined in the whole realm of astronomical studies, as no star yet has been found with a parallax greater than 0.9 seconds of arc, and most of those nearest to us are not greater than half that quantity. When it is considered that personal and instrumental errors must be eliminated for a period extending over one-half the earth's annual revolution, it is not to be wondered that in many cases the measure came out sometimes a plus—sometimes a minus quantity, with instruments used for the purpose before the Heliometer was brought into requisition. I should like to describe this instrument, which indeed has been wrongly named, but time will not permit.

The astronomical camera is also adding largely to accurate astronomical measurements. It was thought at first that the shrinking of the film on the negatives would make stellar distances an uncertain factor, but no less an authority than Dr. Elkin asserts that the photographic charts of the pleiades are as accurate for refined measurements as the stars themselves by the use of the Heliometer, and whereas many of these stellar measurements have to be carried on for years under some of the most trying conditions, by the photographic method, a few hours will photograph all the stars of a group, or cluster, down to the sixteenth magnitude, and then the plate may be leisurely studied and measured in the laboratory without hindrance from cloud, bad definition, or the thousand and one difficulties the astronomer meets in endeavoring to reach his ideal. I could dwell here for all the time at my disposal, but I dare not.

The stellar charts given to us by those grand fellows, M.M. Paul and Prosper Henry, of Paris, by Prof. Pickering and his earnest corps of assistants in Southern California and Peru, as well as other members of the photographic congress; the beautiful photographs of nebula, by Dr. Janssen, of Meudon, Mr. Common and Mr. Roberts in England, and Dr. Von Gothard, in Hungary; the wonderful pictures of the solar surface made by Dr. Janssen, all

show us the triumph of modern photographic manipulations. But the end is not yet. Commencing with the work of our own Dr. Draper and that of Dr. Huggins, we have spread before us to-day charts of stellar spectra which tell us of the physical constitution of those suns whose parallax is unknown, and whose light period may date back to the dawn of life upon the earth. It may be of interest to state that in this research, which has added so much to our knowledge of stellar spectra, the wives of Dr. Huggins and Dr. Draper have both assisted in the charming work, and although Dr. Draper has passed away, Mrs. Draper still carries on the work through Prof. Pickering, and Mrs. Huggins is still at her post at "Upper Tulse Hill."

One of the most wonderful results lately obtained in stellar spectrum photography is the discovery by Prof. Pickering that, at certain regular intervals, the K line in the spectrum of Zeta Ursa Majoris is doubled. The interpretation of this phenomenon is that the brighter component of this star is a close double star beyond the power of the telescope to separate, and that while the companion is rapidly rotating around the primary star, it displaces the lines one side or the other of the normal line, according as it is approaching or receding from the earth.

Two other stars have been discovered with this doubling of certain lines, and it would be difficult to predict what will be the result of future researches in this new field. I could dwell here for all the time at my disposal, but I dare not.

Time measurements in astronomical observatories have reached wonderful accuracy. When our big bell tolls the quadrant hours of the dial, we pull out our watches and are satisfied if we are within quarter of a minute. Fortunately, our astronomer at the Allegheny Observatory is not so easily satisfied. If the stars will but shine, he is not content if the error be sixty times less, *i.e.*—a quarter of a second; and I recently saw the figures for several days' "time" work, where the errors were not greater than three one-hundredths of a second. We all know the great benefit of this time, transmitted to our railroad centres, and if human ingenuity could but have the trains keep time with the stars, we should

never have the paradoxical phenomenon of two trains endeavoring to occupy the same track at the same time.

A recent instrument for accurate astronomical measurement, invented by Prof. S. P. Langley, and constructed at our works, is named by the inventor an occulting eye piece. Experiments have shown that the time of the occultation of a star may be readily determined with this instrument within one-twentieth of a second, and with experience the time may possibly be determined within one-fiftieth of a second, and this perfectly free from the element of personal equation.

In the construction of astronomical instruments greater and greater perfection is being reached in every decade, and the time has passed when the astronomical engineer is satisfied with "cut and try" methods as of old. The mathematician stands by him ever ready with the magic plus and minus, to urge him on to higher attainments, to reach as near as possible to the demands of nature's unalterable laws. The object-glass of the telescope, that marvellous eye that peers into the fathomless depths of stellar space, is now brought to most wonderful perfection, and has almost reached the limit of human possibilities. The refinement of the measurements of its curves may be slightly comprehended by the uninitiated, when I say from personal knowledge and experience that the rubbing of a surface for a few seconds of time with the tip of the finger and the finest of polishing material, may ruin the accurate performance of the glass. The measurements of the curves sometimes reach to the sixth decimal place, and the artist of to-day can determine so minute a quantity with great precision and certainty. In modern investigations of the object-glass of the telescope, no one has done so much to bring it up to the highest standard of perfection as Dr. Charles S. Hastings of Yale University. He has just completed some of the most refined studies in this line that have ever been made, and, perhaps, since the days of Gauss, no such advancement in mathematical dioptrics has been made, which, carried out experimentally, is now yielding most remarkable results.

The work of Alvan Clark & Sons in this line is known to all, their latest triumph being the great Lick telescope.

Paul and Prosper Henry and Secretan in France, Schroeder, Cooke, Hilger, Common and Calver in England, Sir Howard Grubb in Ireland, Merz and Mahler, Repsolds and others in Germany, and I might add other very honorable names to the list who have done a good part in this, one of the most charming fields of modern research, but I must not dwell here further than to mention that in our own country we are rapidly taking an important place in astronomical engineering.

The construction of the mounting of the great Lick equatorial was most successfully carried out by Messrs. Warner & Swasey, of Cleveland, while the great telescope of twenty inches aperture is now well under way at the works of Mr. G. W. Saegmuller, of Washington, D. C., and both these firms have built, and are now building, smaller but no less perfect mountings for other observatories. It is hoped that we shall soon have standard dimensions introduced into all astronomical and physical instruments, and a movement has already been made in the right direction. It cannot come too soon.

In the realms of physical investigation and apparatus, great accuracy has been reached in the past few years. Let me mention one branch in which I have taken an humble part, namely, the production of optical surfaces and the ruling thereon of those marvellous diffraction gratings which have so greatly advanced the study of spectrum analysis. I can well remember when Nobert, of Pomerania, produced his first test-bands for the microscope, and when he produced his first diffraction grating, which, in its entire ruled surface, was but two centimetres square. To-day we are producing surfaces fifteen centimetres square, in which the error of curvature or flatness, as the case may be, is less than one two-hundred-thousandths of an inch; and on which Prof. Rowland has ruled one hundred and ten thousand lines with such precision that the error between any two of the lines is probably less than one three-millionths of an inch. With this instrument of research physicists have boldly entered into new and untrodden regions of nature, and are from time to time uncovering her hidden wealth to enrich the storehouse of earthly knowledge. I present for your inspection the wonderful map of the spectrum of the sun,

which has been so recently placed in our possession by Prof. Rowland. Here, spread before you, is the result produced by the use of the concave diffraction grating, untouched by the hand of man. Here, in the red end of the spectrum, you see the marvellous B group, never before photographed as you see it now. Here you see the great C line and here the D lines, one of which is plainly double, while you see thirteen lines between the D lines. I can well remember when the instrument that would show the one nickel line between the D lines was considered a marvellous piece of work. Passing over the thousands upon thousands of lines between the D lines and the H line, we stop for a moment to examine between the H and K lines. Here is Angstrom's celebrated map of the solar spectrum. If you will examine it you will see he places three lines between H and K. In this photographic chart before you, I count one hundred and twenty-one lines between the H and K. But here Angstrom stops with his chart, because the human eye fails to see satisfactorily much further; but on this photographic chart we have, beyond the H K group, more lines than in the whole of Angstrom's map, as you see extending about thirteen feet on the photographic chart beyond that which is visible to the human eye, and containing thousands of lines. The value in wave lengths on these charts is given within one one-hundred-thousandth of its true position.

Probably one of the most refined studies in which the spectroscope is now being used, is the determination of the stellar motion in the line of sight. No other instrument is as yet able to cope with this difficult problem. When a self-luminous body like a star is moving rapidly toward the earth, it is evident that it is advancing upon its own "waves" of radiant energy, thus shortening them. When it is receding from the earth, it is as it were running away from the waves of radiant energy it is given out, thus in effect making all these waves of greater length. When its spectrum is examined in a powerful spectroscope, the absorption lines are seen to be shifted toward the violet, if the star is coming toward us; if the lines are displaced toward the red end of the spectrum, the star is receding from us, and by the amount of this displacement the velocity may be determined. This study, however, is a

most difficult one, as at best the displacement is very small indeed, and it is only by the most refined and patient work that Mr. Christie, Astronomer Royal of the Greenwich Observatory, has given us our present knowledge of the motion of stars in the line of sight. Much is, however, to be hoped from the method of double displacement which Mr. Keeler expects to use with the great spectroscope of the Lick observatory, as also the photographic method already mentioned in connection with Prof. Pickering's work.

All this has been brought about by work of the highest character requiring refined measurements and manipulation, of which our forefathers knew practically nothing. But the end is not yet. Refined as these measures may be, yet finer and more critical are being done, and we are now constructing a machine called by its inventor, Prof. Albert Michelson, an "Interferential Refractometre," in which this same phenomena of interference is made the basis of measurement which lies close to the border land of human possibilities.

You are all aware that the various enlightened and civilized nations have standards of weight and measure that have slowly been evolved from the cubit, the span, the finger-length and the barleycorn, if you please. Intimately associated with the evolution of standards of measurements are the names of Kater, Bailey, Bessel, Airy, Bird, Troughton, Babbage, Ramsden, Repsold and many others I could name; but in our modern work perhaps few men have done more than our own Prof. William A. Rogers, whom some of you know personally. I here submit to you one of his decimetre standards, in which we have included standards for the centimetre, millimetre and hundredths of millimetres.

But, as I said, nations have their standards. On what are they based? The French metre is presumed to be one ten-millionth of the earth's quadrant, the English yard evolved from the barleycorn, etc., but the measurements of precision in our day demand an indestructible, absolute and unalterable basis for our standards, so that if they all be destroyed the original is still available. Prof. Michelson has chosen a wave length of sodium light as the basis for a new standard, a something that will remain forever of the same absolute linear value, or at least so long as the solar

system floats in the luminiferous ether that, so far as we know, pervades the entire universe. A wave length of sodium light is, roughly speaking, about one forty-two-thousandths of an inch long; or better, five thousand eight hundred and ninety ten-millionths of a millimetre. Now, as this is an appreciable figure, it is evident that any method proposed to measure its *absolute* value must be of the highest accuracy. The method devised by Prof. Michelson in the refractometre has certainly brought the work to marvellous perfection; for in a paper read by him at the Cleveland meeting of the American Association, he showed that the error was not greater than one part in two millions, and possibly would be made not greater than one in ten millions. Gentlemen, can you appreciate such a quantity? Yet here is a physicist, with a high ideal of perfection, taking the pulsations that are sent earthward by the sun, and by methods within the reach of human skill, actually recording them upon a standard bar immersed in a freezing mixture, and giving us a universal standard based upon the absolute value of a wave length of light. You may appreciate some of the niceties in the construction of this interferential refractometre when I tell you that in making some of the optical surfaces for use with it, Prof. Michelson demands an accuracy closely bordering on one millionth of an inch.

With the new instrument Prof. Michelson proposes to carry out advanced experiments on studying the coefficients of expansion of standards, etc., the coefficients of elasticity, and critical measurements of the indices of refraction of various substances. But I must not dwell here, though the theme is as enchanting as Fairy Land. Nations have joined together for the production of standards of weights and measures, and but recently our government has received its new set, of which I hope we shall have a full description in the lecture we are to enjoy from Prof. Mendenhall on this very subject. It may be of interest to you, however, to mention the fact that Prof. Wm. A. Rogers, formerly of Harvard Observatory, has devoted the better part of his life to studying the errors of standards in use in this country and Europe, as well as producing some of the best work in this line that has ever yet been done. Perhaps no living man has worked so earnestly upon

his hobby. For years he got out of his bed at five o'clock every morning to compare his bars of bronze, steel, copper and glass, at an hour when they had swung through their oscillation or temperature changes, so as to be able to determine the absolute value of their coefficient of expansion, as well as to learn whether the material from which the standards were made passed through slow molecular changes or not. Among many important facts he has brought to light, is that of the equable expansion of metals, etc., *i.e.*, that the expansion is equal for each degree within a range from zero to the boiling point, so that it is now only necessary to know the coefficient for one degree, and add or subtract from the standard temperature at which the bar was normal. In the production and ruling of these standards there are so many factors that come in as hindrances to perfect work, that Prof. Rogers must have added to his virtues, that of patience to a very large degree. I have no doubt some of our members call to mind his paper, read in Pittsburg some four or five years ago, before the National Association of Mechanical Engineers, on "A Solution of the Perfect Screw Problem." The great Whitworth said, "a perfect screw was never made," and perhaps he was correct, but Prof. Rogers has brought its solution about as close as any living man, except, perhaps, Prof. Rowland, who indeed makes the best screw possible by mechanical means, and then by studying its errors, eliminates them by one of the most simple, yet beautiful devices, ever applied to the solution of so important a problem. Those of you who may be interested in this matter, will find a most excellent article on the subject by Prof. Rowland under the title, "Screw," in the ninth edition of the *Encyclopædia Britannica.* I here take the liberty to show you a screw made under the supervision of Prof. Rogers in some of his earlier work. Its linear error is not greater than 0.00005 of an inch, but it has unfortunately a periodic error of drunkenness, that makes it useless for the purpose for which it was designed, though for purposes where it can be used in whole revolutions, it is perhaps equal to any ever made. It cost the labor of two of the best workmen of the Waltham Watch Tool Co., for 425 hours, at $1 per hour, so that it cost almost half its weight in gold.

One of the most delicate methods of studying a so-called perfect screw is to rule a diffraction grating by the aid of a diamond moved by the screw. If there are errors of drunkenness as in this screw, the interference is so irregular that no lines can be seen in the spectrum from the grating so ruled. If it is more nearly perfect, the imperfection is made known by false lines or ghosts in the spectrum, and like Banquo's, they will not down until the errors of the screw are eliminated. There are many other methods of determining errors in the run of a screw, some of them of high value, and it is with considerable pride that I say our American machine shops are taking advantage of them to produce better and better work.

It needs no words from me to call to your mind the vast strides that are being made all around us in electrical science, nor is it my intention to elaborate upon the subject. But in connection with the theme of this paper, I may mention the great improvements being constantly made in the refined instruments for electrical measurements. When I call to mind the first induction coil made by Faraday, and which only a year ago I held in my own hands, I compare it with the beautiful and thoroughly practical instruments made within the sound of my voice. Is this not a marvellous age of improvement? Not only do we have our am-meters, our volt meters and our galvanometers measuring currents so minute as one hundred millionths of an ampere as well as the most enormous currents of electric energy, but made just across the way we have our electric metre, measuring out to you and I, the "subtle fluid" in quantities to suit our most fastidious tastes.

I may mention here that science is largely indebted to a little instrument called by its inventor the "Bolometer," for some of the most charming discoveries ever made in the realms of radiant energy. It is essentially an electrical instrument, as its action depends upon the resistance to a feeble current, by a most delicate strip of platinum, which when connected with a delicate galvanometer at once registers forms of energy coming to the earth from the sun, hitherto unknown, yet of so important a nature, that did it not exist, life would not be possible upon this planet. It has brought us news from the sun and moon that gives new life to the study

of what Prof. Langley has well named "The New Astronomy." The delicacy of the measurements made with the bolometer may be appreciated when you learn that under certain conditions a deflection of one millimetre on the galvanometer scale is registered by a current of 0.000.000.000.5 (five-billionths of an ampere) through the coils of twenty ohms resistance, and when the observing telescope is used on the divided scale, one-tenth of this deflection can be readily determined, and if we put this in temperature coefficients, one-billionth of a degree centigrade can be indicated, while 0.000.001 of a degree may be indicated and measured. It is with such an instrument that Prof. Langley has opened a new world to us, particularly in the infra red end of the spectrum, and has told us in the plainest terms that were it not for the invisible rays of radiant energy (invisible to the human eye) human life would be an unknown quantity upon the earth. But I must not dwell on these enchanted grounds, else I may be arrested by the fairies who have no love for long-winded people.

In the domain of civil and mining engineering most of you are far better posted than I, and I would waste time were I to take too much of it rehearsing the improvements due to accurate work and measurements. Constant improvements have been made in engineering and mining instruments within the past decade, and I have been much pleased in my work as an instrument maker to receive some of the very best suggestions from our thoroughly practical engineers. Improvement in micrometers in use in geodetic work have been suggested that are of great value, and constant efforts are being made by our instrument makers to bring them up to the highest accuracy for measurement. In the United States coast and geodetic work the constant aim is for work of precision. As an instance, I may note a recent triangulation in southern California eleven miles in extent, in which the mean error of three sets of observations was less than *one centimetre*. These observations were made by and under the direction of Prof. George Davidson, who was our representative at the late Paris Congress of Engineers. It is to be hoped that our esteemed head of the United States Coast Survey, Prof. Mendenhall, will use his best efforts to send such men to represent and carry out the work

for our government when the nations shall again measure the Peruvian arc as has already been proposed. We have advanced so far in our instrumental construction, in the character of our transits, theodolites, levels, heliographs, etc., that instruments of precision will not be lacking, if we can only furnish that important factor, the eye and brain at the small end of the instrument.

The accurate methods of alignments in the construction of long tunnels have been one of the wonders of the century. As I stood at the Swiss terminus of the great St. Gothard tunnel, my mind's eye carried me through its forty-nine thousand feet of solid rock excavation, executed by the hand of man, guided and directed by men of brains, alignment and levels measured and carried along from step to step until the diaphram became thinner and thinner, and at last Italy and Switzerland shook hands over this triumph of modern engineering skill. The alignment proved true to ten centimetres for level and twenty centimetres for the lateral line. But engineers are not yet satisfied with their achievements. Only a week since I learned of a proposed method of optical alignment that in my opinion will be of the utmost value in work of precision. I should prefer to mention the method, but as its inventor has not yet brought it to perfection, I could not do so without a breach of trust.

Chemistry is also adding to its laurels in the domain of accurate analysis and work, and indeed, while the spectroscope may detect the one three-millionth of a grain of sodium, we have yet to look to the chemist for those highly accurate determinations of quantitative analyses now so commonly characteristic of the modern chemical laboratory. The wonderful development of this beautiful science has perhaps contributed more than all others to supply the wants and necessities of the human race, and there is scarcely an industry to-day that is not in some way dependent upon the chemist for data upon which to carry on their work. So fully does this science enter into the industries of our own city, that every leading rolling-mill and steel works has a completely equipped laboratory and practical chemist, to supply from time to time accurate analyses of their products. Further than this, some of our own honored members are earnestly working toward that

which must come sooner or later, namely, standard chemical equivalents in the various grades of steel and iron. Let us give them our earnest support in this important work.

In mechanical appliances and in modern machine work great strides are being constantly made toward greater and greater perfection, and, as I said in the outset, the mechanic of to-day is not satisfied with the coarse measures and gauges of our early days; but he must have his steel graduated rules, his micrometre callipers, his standard end-gauges, his standard reamers, etc. What the English nation owes to their Whitworth, we, in turn, owe to such firms as Brown & Sharp, Pratt & Whitney, Sellers, Bement, Warner & Swasey, and others for their valuable contributions to metrology, and their standards of various kinds that have contributed so much to advanced mechanics in this country. The standard measuring devices made by Brown & Sharp, including their micrometre calliper, micrometre gauges, Vernier callipers, etc., their hardened steel squares and angles, etc., have become a power for accurate work. I notice it particularly in my own works, where my own excellent workmen have a most laudable ambition to read to the finest possible quantities in their mechanical manipulations, and, as a consequence, we are brought nearer and nearer to that devoutly to be wished for millennium, when interchangeable parts will be the *rule* and not the exception. The standard gauges, reamers, taps and dies of the Pratt and Whitney Company, now find an honored place in all high-class machine shops; and our American machinists are greatly indebted to the labors of Prof. W. A. Rogers and Mr. George M. Bond, who designed and carried into execution that wonderful instrument of precision called the Rogers-Bond comparator, from which has emanated so many standard tools, and which has assisted so largely in the introduction of interchangeable parts in American machinery. Every advanced machinist should read the admirable work published by this company, and edited by Mr. Bond, on standards of length. I am not saying this as an advertisement of any firm, but wish to give credit to our Yankee brethren who have done so much for work of precision in the machine shops of this great country.

But we have yet much to do to bring up mechanical work to the

standard it should be brought to. A few of our best shops have their tool room and a competent man in charge of it, but the day will come when the comparator will be in every tool room, when records in thousandths of an inch will be kept of the size of every important piece of machinery. The mechanic in charge will adjust every gauge and calliper by the comparator, and hold the workman responsible for his work. Watt thought he had attained remarkable accuracy when he bored one of his cylinders so that he could not get half a crown between the cylinder and piston-head. But we are not living in Watt's time, nor in the age of the old Cornish engine; and although we are not to despise the days of Watt and the Cornish engine, we have no excuse, in this advanced and enlightened age, to turn out indifferent work of any kind. Nor is it necessary to dwell on the importance of this accuracy of work in our machine manipulations, for while we have not yet reached an universal standard of interchangeable parts in our machines, every important firm in this country is doing a good share in advancing the grade of their output, and in good time we have reason to believe that precision will take the place of carelessness, and that excellent "rule of three" instead of that ancient and dishonorable "rule of thumb."

It is true that human hands and human brains must have a limit to their capabilities; but where shall we place that limit? Watt gave us the horse-power as a unit of measurement, Joule gave us the better one of the foot-pound unit, King Henry's arm may have served for the long measure, and the barleycorn for the short measure, but the metre and the micron are infinitely superior, yet we still hope for better standards, and are now reaching out for waves of radiant energy from which to make them, and which shall remain as constant as the universe, "whose builder and maker is God."

In the realms of the higher sciences the mind of man has reached, as it would seem, almost to the infinite. The mind may think and think, but human ingenuity is surrounded with so many hindering environments, that it cannot execute the commands of the brain; but we can approach to that boundary line where the

sign-board tells us, in unmistakable characters, "thus far shalt thou come, but no farther."

Sir Wm. Thompson has estimated the size of the molecule to be somewhere between one two hundred and fifty millionths of an inch and one five billionths of an inch, and in that beautiful illustration familiar to most of you, tells us "if a drop of water were magnified to the diameter of the earth and the molecules magnified in the same proportion, that the smallest as noted, would be coarser grained than a heap of small shot and the largest, less in diameter than a heap of cricket balls." Can we therefore ever hope to deal with such infinitesimal quantities? possibly, probably not and yet who can tell what a day may bring forth. The organs of sense in man have some marvellous capabilities. The human retinal nerves, for instance, have astonishing powers of discrimination. Prof. Rood has shown that a flash of light lasting but forty billionths of a second is capable of making an impression upon the human retina. Prof. Langley has shown in his charming monograph on "Energy and Vision," that the visual effect produced by any given constant amount of energy varies enormously with the color or wave length producing it, and that while we may perceive a white light in so short a time as Prof. Rood has shown, yet for the actual physiological processes required in seeing, we require from one quarter to one half a second. He then shows that the *vis viva* of the waves of light whose length is 0.75 microns long, when arrested by the human retina, *represents* work done in giving rise to the sensation of crimson light, of 0.000.000.000.0003, or three ten trillions of a horse power, or about 0.001 one thousandth of an erg, while the sensation of green can be produced by 0.00.000.001, or one hundred millionths of an erg. Moreover, he has shown that the human eye has a vast range in the intensities of lights it can perceive, represented by the ratio of 1 to 1.000.000.000.000.000, or one to one quadrillion. Prof. Nichol has also shown that some human eyes are capable of discriminating tints of color so rigorously as to detect one part of coloring matter in one hundred million parts of white. Here, then, I have given you a few instances of the remarkable powers of one organ of the human economy, an organ that we use

so constantly in all our refined measures and manipulations. Who then can tell the limits of human capabilities for grand achievments in the future? The world's great workshop is open for all of us. She needs master workmen. As the laws of mother nature are more unalterable than those of the Medes and Persians—and if we shall pursue our work in conformity to their demands, so shall we ever make progress toward perfection, and although the goal may never be reached, there is a happiness and triumph in knowing we have taken steps in advance of those before us, and have set the example of patience and progress to those who will follow after us.

Let us then be up and doing
With a heart for any fate.
Still achieving, still pursuing,
Learn to labor and to wait.

The Society adjourned at 10.15 P.M.

B. SPEAR,
Secretary, pro tem.

FEBRUARY 18TH, 1890.

THE Society met at their rooms at 8.10 P.M.

Thirty members present.

Director Wilkins presided.

On motion of Alexander Dempster, Thomas P. Roberts was elected Secretary *pro tempore,* Secretary Wickersham being detained at home on account of sickness.

The minutes of the last meeting were read and approved, with the exception of the annual reports, the reading of which, on motion, was dispensed with.

On the call of reports from committees, Mr. Dempster read the report of the proceedings of the convention in Harrisburg, January 23d, called by the State Board of Agriculture to discuss the subject of changes in the laws affecting the public roads throughout the commonwealth. Mr. Dempster had been appointed by the board of directors to attend that meeting as a delegate from the Engineers' Society.

Report of the Delegate to the Harrisburg Convention, January 23d, 1890.

About one year ago it was your pleasure to appoint a committee to consider the "Road Problem," and present such suggestions for its solution, in this commonwealth, as might appear practicable. The necessity for hasty action was so imperative (made such by the early adjournment of the legislature) that your committee did not have sufficient time in which to collate an exhaustive report, nor digest fully the provisions of a law that would embody the reforms necessary to transform our present code of road laws into a system that, in its practical operations, would give the greatest return of benefits for the amounts expended in the construction and maintenance of the highways of the commonwealth.

The members of your committee, impelled by the inclination to contribute their share in the accomplishment of the object desired, busied themselves in collating data, formulating a report and suggesting what seemed to them desirable provisions of a law relative thereto, which they presented to you at the meeting last March for your action, and which you were pleased to approve, order to be printed and sent to the legislature, in the hope that it might receive favorable consideration by the law-makers of the State. Before it reached the point of distribution amongst the legislators, it was decided (and I think very wisely, too) to postpone further consideration of the subject until the following term of the legislature.

As a result of such action, our proposed law was "shelved" "pigeon-holed" or sent to the "waste basket," and "thusly" our "labor was lost," so far as receiving any attention by the persons for whom it was intended. The recommendation of the Governor relative to the improvement of our roads had the effect of stimulating a number of persons, law-makers and others, to go into the business of offering something better than we had *on* our statute books. Many of the bills offered were specimens of crudity, and bore the unmistakable ear-marks of haste in preparation of "undigested ideas." Our own presentation might be classed in the same list. The apparent incompleteness of all the bills pro-

posed, and the lack of time in which to properly mature a satisfactory law, added to the importance of having the embodiment of the *best* judgment, the fullest information and enlightenment on the subject, induced the legislature to intrust the formulation of a law to a commission constituted of five members of the House of Representatives, three of the Senate, and five citizens appointed by the Governor. Thus the whole subject was left to be matured in the minds of said commission, and the provisions of a law to meet the requirements of the case to be formulated and moulded by them.

The appointment by the Governor of the citizen members of the commission was made about the close of the year, amongst whom is our "honored townsman and fellow-citizen," David McCargo, Superintendent of the A. V. R. R., as one of its members.

The various bills which had been presented in the legislature prior to adjournment (ours was not amongst them) were collected and bound into pamphlet form and placed at the disposal of the commission for their perusal if they so desire.

The members of said commission met and organized for the work assigned them, in the city of Harrisburg, on the 22d of January, which time and place were opportunely coincident with the annual meeting of the Pennsylvania State Board of Agriculture and General Farmers' Institute; who actuated, too, by the desire to contribute their quota of force to the already increasing current of public interest, had, through their executive and advisory committees, made the question of "road laws," "road construction," and "road repairs," the leading topics of their meeting, and which occupied their full attention. On Thursday, the 23d of January, in order that the consideration of the subject might be made the more general and profitable, and that all sections and all interests might be represented and heard, they had extended a general invitation to all agricultural and other organizations interested therein to send delegates to said meeting, empowered to express their views on the important points to be considered in connection with the general theme. Thus the members of the commission had the opportunity of hearing the subject discussed by the fully accredited representatives of the agricultural interests

of the State, and who are the embodiment of the wisdom, judgment and ability of the farmers of our State—and abundantly qualified to speak for, maintain and promote their interests. From the expressed opinions the commission no doubt quietly housed away in the granaries of their minds, gleanings of wisdom and thoughts expressed ably and well that may prove beneficial to them in their future deliberations, and of which we may realize some benefits when they are crystallized in the report of said commission. It seemed to be the earnest desire of the State Board of Agriculture to elicit as much information as possible on the subject, and of the commission to absorb as much thereof as they may deem essential in their work.

There were delegates from the States of New York and Massachusetts, who, with those from our own State, agreed without exception that the need of some change for the betterment of our roads was urgent and great; all can unite on this line.

It pleased your Board of Directors to send a delegate to that meeting for the purpose of showing the interest *you* feel in promoting the needed reform. He, in company with the delegate sent by the Chamber of Commerce (and who is a prominent member of our Society of our city) and another member of our Society who is enthusiastic in the promotion of every good work pertaining to public improvements, Arthur Kirk, Esq., attended the convention, arriving on the prompt time, in fact 24 hours sooner than was necessary, through the misinformation contained in a telegram to Mr. Kirk of the time that the subject would be taken up by the convention. According to the programme, the consideration thereof was assigned to Thursday morning, January 23d, at 9 o'clock. At the convening of the meeting, the Governor of the commonwealth took the chair, and proceeded in his usual able and eloquent manner to review the road laws of our State, and point out their defects, making suggestions relative thereto. His earnest and forcible treatment of the evils existing and the benefits to be attained by a sensible reform in the laws of the commonwealth, so as to bring their provisions within the operating lines of "common sense" was clear and convincing; but it would

occupy too much time to give even a synopsis of his speech, so I will not attempt it.

He was followed by N. T. Underwood from Wayne county, who read a carefully prepared paper on the "Public Road System," the whole tenor of which was, that there was a *want of system* in the great diversity of regulations prevailing in the different counties of the commonwealth produced and placed in the statute books of the State by the pernicious class legislation of the bygone years preceding 1874.

The next paper, entitled the "Road Laws of Pennsylvania," read by Mr. J. A. Gundy, of Union county, followed in the same general strain of adverse criticism on the present laws. These papers will be published, and no doubt copies thereof will be placed on the file of the Society. Thus the subject in all its different phases and principal features was brought clearly before the convention and discussion elicited. Wm. H. Rhawn, Esq., Chairman of the Board of Trustees of the University of Pennsylvania, opened the discussion by referring to the interest manifested by a number of gentlemen of that city, who had inaugurated a movement well calculated to call attention to this subject, by offering cash premiums for the three best papers on "Road Making and Maintenance." He showed that there was a general dissemination of interest in the matter. His speech was supplemented by Mr. Lewis M. Haupt, who in a very carefully prepared statement of facts, which might be termed a "scientific treatment" of the subject, illustrated the worse than extravagant waste of horse-power at present required to move the products of the farm from their initial point of production, to market, or to some of the great rail or water highways in the State. His comparisons were of different classes of roads and of the comparative cost of moving a ton on any of the roads, taking as the standard the cost of transportation of a ton of ocean commerce. The comparisons were interesting and fully convincing as to their correctness. The dissemination of "bright rays of wisdom" from those "wise men of the East" was well supplemented by the not less brilliant and perhaps more practical from the western metropolis of the Keystone State. I mean the delegate sent by the Chamber of Commerce of our city,

who, in his usual vigorous style, portrayed most lucidly the benefits that would accrue to the inhabitants of our commonwealth as the natural and legitimate results of good roads, and when he sat down I regretted that he had not been sent as the accredited delegate of the Society instead of that of the Chamber of Commerce. Your representative, fully impressed with the force of the facts that had been thus presented, deemed that the line of discussion which had been followed had fully and clearly expressed all that could profitably be said in that direction at that time, and believing that the "physical features" of good roads will be cleverly dealt with when the time arrives in which the engineer will be given opportunity to display his talent and ability in "road making" (for it is not because there are not engineers in the State of Pennsylvania that there are bad roads, and not because of any lack of ability possessed by the members of the profession that they are not properly maintained; for a thousand engineers could be found if their services were needed, who could and would construct good roads), endeavored to change the trend of the discussion into the channels of present requirements, and attempted to show that the urgency lay in providing *ways* and *means* which would enable the engineer to exhibit his ability in "road making," and to conclusively prove that such is not a "lost art," and, as speaking for the Society, he took the copy of the proposed law which you had approved last March and attempted to show that it was worthy the candid consideration of those entrusted with the revision of the present law, yea, that it was worthy of their support, approval and adoption in at least some of its provisions.

He does not flatter himself nor congratulate you that his attempt was satisfactory to those who heard, as it was not certainly satisfactory to himself; and the most he reports in the case is that the benefits that would accrue to the public by the enactment of the law approved by this Society would certainly prove greatly beneficial to the interests of the people, were tersely, though not eloquently presented; and as the authorized commissioners for the revision of the law were present, the benefit accruing from having their attention thus called to the recommendation of the Society and the results of its efforts in that direction were given a place

amongst the many suggestions in the form of legislative bills, that had been collected into pamphlet form as before stated; so that to that extent your delegate was successful and the object of your sending him to the convention at least partially attained and the Society placed in the foreground as an advocate for the necessary reform. Amongst the multitude of those who are laboring on the same side there are many who want to attempt too much and scatter their energies over the extended area of the whole field, but it seems to be the part of wise judgment to concentrate all our efforts on the requirements of the "legal stage" and after the best that can be procured in that direction has been obtained, then take up the next or "scientific stage," if you choose to call it so—treat it intelligently and well, and evolve the best that the professional ability of the State can produce. No fear need be entertained, no, not for a moment—that the profession will not be equal to the demand and the strictest exactions of an economic and practical application will be met to the full. I do not think it is yet the time to engage in the discussion of the "smoothest road" over which a team may haul the largest loads to town, or the greatest number of bushels of corn to the mill. That may come later and at a time that will be better than now. Many in following out their bent on that line would suggest expensive constructions which cannot be obtained as a rule, and have the effect of causing a feeling that they had better endure the evils of bad roads that they are thoroughly familiar with and have endured so long, than to fly to those of extravagance, the extent of which they do not know. Fearing the requisite increase of taxation, many will oppose any change, lest they should get too much change. I say, then, that the efforts should be limited to procuring the enactment of a judiciously-liberal law—the operations of the provisions of which would not be oppressive and still provide funds to enable the properly legalized authorities to construct roads by sections that would in a few years aggregate many miles of "good roads." The convention closed the discussion with the recommendation that the present law needs to be changed, that the custom of working out the road tax is altogether unworthy the support of an enlightened people, and that the construction of

roads should be placed under an intelligent head (they do not say an engineer, as that term seems to convey the idea of expense beyond their means). Beyond this I believe they did not go. Looking over the whole field, with the knowledge that the farmers are a power in politics although scattered throughout the State, whose influence is invested with potency in the framing of the laws by the operations of which they will be called on to pay money in the form of taxes, their opinions must be given consideration. The action that may seem to some enthusiasts too conservative, will more likely obtain desired results than any radical change by which the farmer would be unduly burdened, and in view of the present status of the case and the probability that there may be further opportunity tendered to express the views of the Society at some future time prior to the adoption, and may be prior to the offering of any proposed law, I would suggest the appointment of a committee on roads, to give the subject attention until such time as the Society is satisfied that it has accomplished its work along that line of utilitarian action. All of which is respectfully submitted by your delegate,

A. DEMPSTER.

Upon the reading of the report, on motion of Mr. Davison the committee of last year, which had the subject of roads in charge, was authorized to continue its sessions, and report from time to time to the Society.

The members of this committee are: Thomas P. Roberts, Alexander Dempster, Thos. H. Johnson, Charles Davis, Arthur Kirk.

The Secretary *pro tempore*, by direction of the Society, cast a ballot in favor of the election of Simon H. Stupakoff to membership in the Society, Stupakoff having been recommended by John Naegeley and Charles F. Miller.

A. Dempster, then, as the regular order of business, read the following paper on the subject of

THE ROAD PROBLEM.

In following along the line of general ideas that have been advanced in promoting the movement for a revision of the "road

laws" of the State and the adoption of such amendments thereto as would make the operations of their provisions more effective in procuring a betterment in our road system, differences of opinion are expressed and divergent views entertained as to how such "betterment" can be best and most readily obtained. It is an old proverb "that in the multitude of counsel there is wisdom," and it may be truthfully said that the evolution of wisdom can be secured by a full and free interchange of opinions and untrammelled discussion of the subject submitted.

With this in view, it is my present province to present the "road problem" before you to-night, to educe from you the very "cream of your wisdom" and the best of your judgment; so that whatever action your committee (to whom you have entrusted the subject) may take in the future, its members may have the benefit of the very essence and concentration of your ideas thereon, hoping that the light thus turned on may reflect credit on our Society and make it a potent factor in the production of desirable results. My theme is not "road making," and my paper is not a treatise on the science and practice of "road construction and maintenance." Neither is it a compendium of the power and energy required to move a ton on the different classes of road from the properly maintained macadam road to the "mud roads" with which we are all now thoroughly familiar; nor a comparison of the good with the bad to convince you that "better roads" are a necessity. There is not a citizen within the confines of this broad commonwealth to dispute it, for every one (be he resident of the city or denizen of the country) agrees, that the evils and inconveniences to which we are subjected should be removed, and remedial measures inaugurated that would operate in the effectual transformation of the present system to a greater degree of efficiency, from which more beneficial results would flow. It is the unanimous opinion that some positive, earnest and energetic action should be taken without delay, towards procuring the desired end. Seldom, if ever, has there been such unanimity in the expression of public opinion as there is at the present time. The exceedingly wet weather of the past season has emphasized the great need there is for improvement in methods and scope of

our present road laws and their operations. The "country roads" have been almost impassable and the products of the farm have been kept in the "garner and barn" when they should have been taken to the markets of the cities and found their way into the channels of public consumption and been made contributory to the quota of nourishment that constitutes the bone and sinew of animal life. All are dependent on the offspring of the soil, as it is the basis of all material wealth; and the ways and means by which it can be most cheaply and readily transported from the initial point of production to the terminus of consumption enter largely into the economics of any country. Now, when the attention of the people of the State has been so prominently and generally directed to the subject, seems to be an opportune time to join in the movement, and by voice and action aid in directing public opinion in the proper channel and in giving point and purpose to the reforms that most clearly and explicitly lay claim to our approval, and endeavor to infuse into the movement such degrees of energy of action as its importance demands.

The transformation of the heterogeneous elements that constitute the practical operation of our road laws throughout the different counties of the State into such a condition of homogeneity, that they will be made responsive to the requirements of the times, and work without friction and loss of power in placing the necessary means at the disposal of the properly authorized officers of the State and locality, to enable them to carry into practice the theories and principles that intelligence and economy suggest in the practical construction and maintenance of our roads and highways.

It is a very easy matter to criticise existing evils, unerringly point out the radical defects of our present system, to unsparingly condemn the incongruities of the diversified provisions that mar our statute books relative to the repair of our roads, and to join in the general chorus for reform. But a practical solution of the problem—one that will meet all the conditions of the case—will be found difficult of attainment.

As balloons are not yet used as the vehicles for transportation of commerce, nor are the highways of commercial traffic, and the lines of social and domestic travel made of "wind," neither do finely

spun theories make a good basis for a solid road-bed; but as "money makes the mare go," so it is money that makes the roads on which the mare shall go to the best advantage, and the road problem of to-day is how shall we procure more money, and how shall it be more intelligently and economically applied?

I know and acknowledge that the money derived from the collection of the road taxes is not properly applied. The wheel of action has so long moved in the line of annual repetition, that it has worn a deep groove or rut of custom and habit in the popular mind, and it will be hard to remove it therefrom; but whenever the proposition is made to increase that tax, a pressure of resistance will be felt as a retarding resultant to such advance movement. If it can be shown that good roads can be procured without the increase of taxation, then there will be little or no difficulty experienced in effecting all the reforms that the most enthusiastic and sanguine promoter could desire. But the proposition or suggestion for improvement, however feasible and beneficial, if accompanied with the addendum that it requires more money and a larger tax duplicate, will not be found palatable to the popular taste.

When such a change is proposed as will require the farmer to mow, cure and put up a ton of hay, and take it ten or fifteen miles to market to provide ten or fifteen dollars to pay his road tax, instead of being permitted to engage in the "frolic" of working on the roads to that nominal extent, and thereby having the duplicate satisfied opposite his name, it will be considered of sufficient magnitude to make many think twice before they act; this, however, can be overcome, and the popular denunciation of the present evil has become so great that no opposition can stem the current.

If the surplus money needed for the improvements can be supplied without calling on the farmer for any extra amount to that which he has been accustomed to pay, then he will not likely demur; but any increase on him will be met with a frown. He earns his money, as a rule, by small aggregations; he labors early and late and all the year round, and counts by pennies the value of his toil. He feels that his farm is made the basis of the bulk of taxes; feels that he is contributing more than his share to the pub-

lic purse, and that he has been unjustly dealt with by the "powers that be;" and he is led to the conclusion, that whatever of increase there may be required, even for demanded and acknowledged improvements, should be derived from other sources than his well-tilled farm. This may be considered and termed narrow, prejudiced and selfish, unworthy the support of an intelligent and liberal people. But it exists, and must be taken into the account, in considering the opposition to be encountered and overcome in the allowances being made along the line of improvement.

The fact exists, and its influence must needs be dissipated by unanswerable argument in showing that the greater expense is the greater economy, and that the old methods have been conducted on the "penny-wise and pound-foolish" principle which operates to the injury of all concerned.

Let me, within parenthesis, remark, that the present system of working out the road tax is charged on the tax duplicate, and that the amount thereof is the price or measure of value of what has been paid for the actual results accomplished. The debit is not correct, for the amount actually expended in labor and skill could be procured in any market where labor is purchased at a fair price at often less than one-half what the books show as the supervisor's pay-roll; the other portion is dissipated beneath the tempting shade of some umbrageous tree by the wayside as the idle moments fly, when "country gossip" entertains the listening crowd. The receipts of the duplicate are more in name than in reality, and are absorbed without reflecting corresponding rays of benefit to the travelling community. The customs of the past that have crystallized almost into the formation of unwritten law require a refusion in the refining pot of common sense, and a recasting into the moulds of present requirement.

As it is the intention to so direct the present efforts that they shall evolve into a wise, intelligent and practical codification of statutory enactments that will best conserve the interests of the public, the public mind should be educated from the "old ruts" into the new and better methods adapted to the wants of the present time.

Arguments of the most convincing character must be adduced to

influence the taxpayer to unite and instruct the law-maker to alter and amend the fossilized statutes of the past that fail to meet the requirements of the day, and in the exercise of a liberal and wise discretion make provision for public necessities of the present régime. It should be clearly and logically shown that the farms strung along the lines of good roads will be greatly benefited; the day has been when the proximity of a farm to a turnpike was taken as an element of value, highly estimated by the owner, and fully discoursed upon when that owner endeavored to effect a sale. The same rule would operate now to the same extent as it did then, but, unfortunately for us now, and especially in this part of the State, we have not a "good road" with which to make comparison of the "bad." We do have a few fragmentary sections of the turnpikes of the past, but they are being worn down to the very "substratum of their constitution," and soon the last "coating" from the virgin clay will have disappeared, and unless the present movement will produce results to counteract the general decadence, all will be on the same level, and in seasons like this all will be "stuck in the mud."

In the urgent desire to get away from the present "environment of mud," and to attain to the highest plane on the line of improvement, there may be the inclination to go beyond the limit that public opinion will ratify and support. The danger of rebound from one extreme is to carry to the other extreme, as if the point which constitutes the centre of gravity, and the point at which it will eventually settle, was entirely unworthy of notice. That may have its illustration in the present movement in the attempt of some enthusiastic reformers to accomplish what is unobtainable at the present time. It is certainly not the part of practical wisdom to place our markers so far in advance of the lines of "public opinion," that there is no probability of ever bringing that "opinion" up to it in "action." Whilst it is "good generalship" to keep pressing forward and to place his banners on the very parapet of the enemy's entrenchments, yet it is neither prudent, wise or practicable to attempt it in face of the patent fact that his banner would be captured and nothing accomplished by the effort. His advancements should be made with the probable surety of success.

So let ours be *towards* securing the farthest point of advance in the line of reform.

Employ all the advantages which can be made available in the movement; concentrate and direct the current of popular enthusiasm to the scouring out the shoals that would impede its progress and let the "mercury" that measures the public pulse rise to the highest degree attainable by the "warm wave" of public discussion; able and eloquent, if you will—but fail not to perceive the advance limits of the indicators that show the full extent of assured improvement. Under the influence of this general rule let us review the provisions of the law proposed by our Society as a substitute for our present laws on the road question, in order to derive the benefits arising from a maturer consideration of the subject and see wherein it would fail to meet the demands and supply the wants of public requirement in the case; remedy its defects and prune its excrescences with skilful but unsparing hand; so that our Society may occupy the position of prominence that the interest and intelligence of its members fully entitle it in the movement, and to which the clear judgment reflected in the proposed law may commend it. Though all roads led to Rome, all were not of the same importance to the great current of travel flowing to and from the "Eternal City," and all roads have not the equal prominence as public thoroughfares of travel now; and it is a natural classification to divide them into general grades—those that are the leading and direct avenues of travel to and from great centres of population and to which others act as mere "feeders"—and those which are the "feeders." The former constitute the lines of travel, while the latter act as links connecting the former into a conglomerate network of accommodation for the wants of the people, and on this basis the classification has been made into two divisions, viz., "highways" and "roads," names short and suggestive of the class to which they belong; they are explained in the draft of the proposed law and need not be here repeated.

It is a matter of small moment who shall make the classification, but it seemed that a commission of four men from the different parts of the county, and thoroughly familiar with the facts in the

case, with the engineer, would do the work as intelligently and fairly as any others who could be entrusted with the work. It may be that the county commissioners would have time to do the work, but this I very much doubt, as that body has its own special work to do, and which will be largely increased in case the proposed law should be enacted and go into effect. In counties where they are not so burdened, it might be a small saving to assign that duty as part of their labor, as it should be the aim of any reform neither to increase officials nor add to the burdens of the taxpayers by promiscuous distribution of funds or extravagant liberality in their amount, without reference to the services performed. Assuming such classification to be made, a serious and important question presents itself for answer: Who shall have charge, supervision and control over them? The character and importance of these thoroughfares naturally suggested the classification into two grades, and it would seem that those denominated highways and which are practically county roads, should come under the control of county officers, and who so naturally should constitute a board of public works, or public improvements, or of bridges and highways, if you please? As the county commissioners in conjunction with the engineer to whom shall be entrusted the duty of determining the amount and character of the work to be done under the special and binding limitation that a certain portion of the funds are to be applied to permanent improvement and to mere repair, and to be governed by such regulations as will secure fully competitive freedom to all inclined to enter the lists as bidders for whatever work can be properly done by the contract system.

Then the question occurs, Who shall have the control of the maintenance of the "roads" which are embraced entirely within the township lines? The township may be termed the first or lowest political sub-division that has officers elected to manage its affairs. The people now elect their own supervisors and other officers, a right they certainly have and should be permitted to enjoy. The evil is that there is no qualification required of the persons they elect as supervisor and in very many cases, sufficient I may say to make it the rule, that men are elected without the

qualifications necessary to make an efficient officer. When the supervisor is elected he has full control and management of the roads, and has no authority or counsellor by which he may be restrained or advised. The "tax duplicate" is placed at his disposal for the disbursement of which he is chargeable, and as a rule the debits standing therein against the several taxpayers of the township is commuted into *labor*—which, as I have before stated, is not judiciously employed; and if it were and the amounts paid into the treasury in cash, they would not be sufficient to make any permanent improvement on the roads, and before such can be hoped for there must be an increase made in the amount of road tax as well as the employment of intelligence and economy in its application.

It is an American principle, and one from which we would not detract an iota of importance or force, that the taxpayer should have a voice and vote in the election of the men entrusted with the expenditure of the money they pay into the public treasury for local purposes, and it is perfectly natural that they should endeavor and insist upon the maintenance of that right. On a line with this general principle, the committee deemed it proper to recommend the election of three road directors, who should be entrusted with the power of taxing and disbursing the money needed in the township for road maintenance and repair. Associated with these, as a board, would be the engineer clothed with such authority as would enable him to employ efficient laborers and assistants in the doing of the same intelligently and economically.

It may be asserted that these road directors, handicapped by the custom of former years, would not assess any greater amount, or at least not a sufficient amount, to better the condition of the roads in the district. Assuming this as granted, the roads would not be any worse and the money as now received would be more effectually expended under the direction of the engineer, which would certainly be a benefit. The limitation of expenditure to the line of 70 per cent. for repairs and 30 per cent. towards permanent improvement would add to that benefit, and would in a few years result in having some fairly good roads. The taking

away of this right would be very unpalatable to American citizens, and I do not think it should be attempted; besides, if a few "fogies" of the "old régime" would persist in a township here and there to the old habits, they would be so comparatively few that they would be looked upon as specimens of antiquity, and be interesting as relics of a by-gone age, and serve as landmarks for comparing the new with the old.

Another provision proposed, and one which is of rather a radical nature, but based on the principles of the greatest good to the community and public, and one whose benefits would be liberally strung along the line of coming years for the enjoyment and comfort of all who ride or drive or draw a load to market. I mean the method suggested for the location and opening of new roads, and changing the location and vacation of old ones. The road system of our State and country has been an evolution from crude and unnatural causes.

The early pioneer, wending his way through the virgin forests of our land, left his mark upon the trees to show the direction of his travel and direct the pathway of his feet, and that became the line of travel. His eager desire to avoid the ambush of the valley taught him to provide a securer path over the hills, and thus the shortest way was sought out between the points to and from where he was going, and that afterward became the bridle-path then the wagon-way of the backwoodsman, and adopted even as the highways of internal commerce, and were used as such until the bands of iron and steel, on smoother gradients laid, became the great highways of trade and travel. It is incumbent upon the engineer and those in authority to change the location of many of the roads that are practically obstructed by steep gradients, and in order to insure the elimination of personal interest or prejudice in establishing for all coming time the routes of travel, it is proposed to submit the location of roads to the said road directors and the engineer, the latter being limited in his action to the procuring of the best gradient, the shortest line, and the least damage and expense in construction, if you will, consistent with public utility. Thus and thus only should roads be determined. For the steepest gradient on a road determines the

amount of the load that can be hauled over the same, and if a road, say 10 miles long, should be for 9 miles of such grade that a team could haul a load of one ton over the same, and that of the other mile should be such that the same team could not haul a load of more than half a ton up it, then the load over the whole 10 miles is limited to one-half a ton with all its consequent loss to the person so hauling, or he must have extra horse-power to haul the load up the excessive grade, and thus lose one-half of the power thus engaged. Either of which cases is a loss that should be entailed for all time, as an encumbrance on the future generations. There may be some prejudices hard to be overcome in the accomplishment of this, but less than this should not be accepted.

The matter, too, of opening up the roads, when located, is also removed to a plane above the control of petty prejudices and small selfishness.

The board and the engineer having once proceeded in the line of their duty as defined and passed upon the opening, it is a way opened to travel that no man can shut by outside pressure illegitimately applied.

Another question is propounded: How are the revenues to be raised and the road and highway funds to be constituted and maintained in order to provide for the annual expenditures that will flow as a stream, large or small, according to the determination of the powers that be? The answer to this seems naturally enough to come in response: Let the roads that are local in their character and importance be provided for by the local authorities, and the funds necessary for their maintenance and repair should be provided by the people who are locally benefited. Burdens to be borne in proportion to benefits received is a law so fair on its face that it needs no further recommendation to secure universal assent, and with the thread of its provisions running through the whole line of requirements, there need be little difficulty experienced in adjusting any differences into the cushioning cavities. All *benefits conferred, have their corresponding responsibilities to be admitted and given*, and thus the county and State would be called on to contribute, or rather supply their proportionate share of the funds

necessary for highways and bridges, by which benefits extended are general in their operations, and which the general public are at liberty to enjoy.

A very important feature of the whole subject, and one which interests us professionally, is the qualifications of the man who shall have general supervision over all the work in all the townships of the county, and have oversight over all the work of the county. The work to be done is of such a character, that a large discretion must inevitably be placed within his reach. He must not only be a man of good judgment but a man of extended practical experience with men; a civil engineer of undoubted ability. He should have the power of appointment of all his assistants, and be made responsible for their efficiency and good conduct.

All the requirements relative thereto should be strict and fair. No man of proper ability need to be afraid of requirements, however rigid, provided they are within the bounds of reason, and this, I think, has been kept in view by the law proposed. There is, in close connection with the duties of the engineer thus defined, a matter that has received little or no attention in this State; at least, I am not aware of any; that is the geography, or, I should say, the topography of it.

This should also receive attention. The States of New Jersey and Massachusetts have made topographical maps of their territory and published the same; that of Massachusetts is particularly well done, and presents at a glance the whole country to a practiced eye in its varied features of hill and dale, and valley and mountain, and river and lake.

There may be an objection that the work will not be worth the money expended, but that is too contracted a view to be entertained by an intelligent, progressive people. In order to secure uniformity of action and regulations amongst the several counties of the commonwealth, and combine the whole under one general head, a "State Engineer" should be created, who would infuse energy and effectiveness into the county engineers that would entail great and at present unimagined benefits. One week in the year, conventions for the promotion of the welfare of the department and conferring blessings on the community,

could be held profitably to all, and much good that is now unthought of would flow through that channel. This needs no elaboration and no discussion to command commendation.

Much remains to be said, but the limits of this paper have been reached, and I will not pursue the subject further at this time, but refer you to the law already proposed for fuller details. The continuance of the Road Committee will place the members in the position of continuous interest on the subject and no doubt they will be able to offer something further by way of improvement on said law, and they stand ready to hear, as they desire to elicit all suggestions bearing on the subject. So please consider that suggestions and discussion are cordially invited, and accept the invitation.

Discussion.

W. G. Wilkins: Of the township adjoining Philadelphia on the west, some years ago A. J. Cassatt, at that time Vice-President of the Pennsylvania railroad, was a resident, and I believe is yet. He was very much disgusted with the way the road tax was worked out and the condition of the roads. He determined that a change should be made, and so he announced himself a candidate for township supervisor. He was elected, and horrified the farmers very much by spending the entire amount of the tax on a very short piece of road which he macadamized. The farmers had not been used to that sort of thing. They had been used to having a few dollars spent here and a few there and let that go. Mr. Cassatt continued his method from year to year until to-day Merion township has the best roads in the State of Pennsylvania. I do not think there is a road in the township which is not macadamized. The farmers now speak in the highest terms of what Mr. Cassatt has done. The roads of Merion township are the favorite drives outside of Fairmount Park, and the favored part of the county for bicyclists. The only expense that the township is put to now is a very small one for repairs from year to year. The principal amount of the tax is expended in summer-time in sprinkling the roads. Mr. Cassatt had water tanks put up at different points throughout the township, and the roads are kept well sprinkled.

Taking everything into consideration, they have the best roads in the State. If that method was pursued in all the townships, it would not be long before the roads all over the State would be in the same condition.

A. Dempster: In the proposed law, which was favored by this Society, there might be some changes of advantage, and I think it would be very well to take that law and see if there can be any improvements in it. Then we shall present it in such a way that it will have some effect. It must be so matured that there can be no flaws found in it. We must try to occupy with it the position we now occupy. I think it is the best bill which has been presented so far as practical judgment and good common sense are concerned.

T. P. Roberts (on being asked what was the heated discussion which had occurred between himself and M. J. Becker before the meeting was called to order): It came up in this way. It is a matter of some interest just now, as it had reference to an article in the *Dispatch*. I had said that I had read an article in the Pittsburg *Dispatch* in which the author, who signs himself a "Mechanical Engineer" (he is a very good writer), says that the Society of Engineers, and the persons who have been in attendance at these conventions, and passing resolutions endorsing macadamized roads, do not understand that this is the age of iron. The day of stone roads is over. He says that the road he would advise would be very much cheaper than any macadamized road, and it would be simply a line of plank in the road, with a flat iron rail, about six or eight inches wide, on the plank, of course making proper connections at the joints; that that would always be passable, because the wheels would be on this iron rail, and so would not have the shearing force that would be exerted on the road proper. If it is possible that roads will never get muddy, that would certainly accomplish a great object. I said to Mr. Becker and Mr. Dempster that I had lived for several years in South America on the line of the road across the Mantiquera mountains, on which coffee is carried very rarely in wagons, usually on the backs of mules; and that it was the muddiest road I had ever seen in my life. In the rainy season there I have seen mules die right in that road. There

is where the battle opened. Mr. Becker said he believed the story until I got to that point about the mule dying, and I had to make a little correction in regard to that. I may as well state that, because Mr. Becker will say I did not tell the whole truth.

When a mule became exhausted they simply removed the packs from their backs, and left them lying in the road, and then the buzzards came down and finished them. They pick the mules' eyes right out. I have seen many mules die right in the roads there, with the aid of this process.

This subject of roads is one of very great importance in my estimation. It is one that seems to engage the serious attention of engineers. The problems are very simple so far as the construction of the roads is concerned. What we want is the means to build the roads. I have been very much entertained by what Mr. Dempster has said to-night, but there is one point I do not think he has dwelt sufficiently upon. That is universal taxation provided for all over the State by the counties, so that all people should be taxed, particularly the railroad corporations, which are now exempt. It was brought out at the Harrisburg convention that the people of great wealth had gravitated to the cities, and the farmers are paying all the expenses; still, the farmers are entirely too poor to build roads, and so comes in very well this classification of roads. The county roads would be built by the general tax from the county. A very interesting point comes up in that connection that I have not seen any notice of. In the city of Philadelphia the people are very anxious to do something for the benefit of the roads all over the State. They had a very good delegation at Harrisburg; very intelligent gentlemen from the University of Pennsylvania, and others representing a large public meeting which had been held there, and at which George B. Roberts and a great many prominent business men of Philadelphia, wholesale merchants and others, were present. Now, under present city laws, they have the right to lay out the streets, and they can expend the money there, but they want the right to spend money also outside of the limits of their county. That is probably the only county which comprises simply the city itself. But the money cannot be expended out of the county without special legislation. Now the

question comes up, how can they make a law by which the wealth of Philadelphia can be utilized to assist in the construction of roads throughout the State? In addition to the general county tax, there may be some contribution from the State. In that way only can I see that Philadelphia can be brought in to help build the roads in the adjoining counties or throughout the State.

W. G. WILKINS: The remark Mr. Roberts has made regarding the State assisting in the improvement of the roads reminds me that the other day I was in conversation with a gentleman from New Jersey, and this subject was brought up. At that time I did not know that the subject would be brought up here or I would have obtained more information from him. For ten years he said they had been trying to get a State law passed which would allow them to improve the roads. They finally got one passed at the last session of the New Jersey Legislature. One of the points of the law was that there should be main roads selected from county seat to county seat, to be improved, and the State would pay for one-third of the cost and the counties through which this road passed the remaining two-thirds. It seems to me that the proposed law of Pennsylvania might include some provision of that kind.

A. DEMPSTER here read the provision in the proposed law covering this point.

T. P. ROBERTS: I had the impression that was to go to the general fund of the State; that it did not specify to be employed on roads.

A. DEMPSTER: Yes, it goes into the highway fund.

A. KIRK: I would take issue with the writer of the paper on one point, and that is that the township officers should have anything to say about the management of the roads. I was in favor of that at first until we further discussed it. When you put up any men of the township to decide about the road here you come into the local entanglements of relationship. They will say: "You shall not run it so as to cut my father's farm or my brother's farm, and all this and that," but if you make the location and management of the roads entirely independent of any local influence, then you will not only make good roads for the neighbor-

hood, but will make good roads for the State. A road is not the private property of the township. It is made for the State, and the State should have the control of where that road should be located, independent of any local influence whatever.

I have known cases where you have climbed one side of a hill, got up to the summit of it, turned at an angle of 45°, and described a mile and a half where half the distance would have done and the shorter line would have been almost on a level, but it would have cut my father's farm. All such nonsense as that would be avoided by having the same system applied to the roads that any intelligent railroad company does to the location and maintenance of their line, where you have a chief engineer; then you have assistants for this division and that division, and each has his assistants and so on down, and every man responsible for his part. If you have township officers to come in and interfere with this chain of responsibility, why it would be something the same as if the stockholders in the neighborhood had the right to appoint the track-layers on the road of the main line. It would just produce division and break down responsibility.

I admit there will be difficulty to have such a law passed. There will be difficulty to get any road bill passed, and we must see to it that whatever bill is presented shall be as perfect as we know how to make it; let us have an engineer to do the work or let them stick in the mud. There is no use in half doing the thing. It is just as easy to remedy the evils of it now, and it seems as if Providence had sent us a season to show all the evils of bad roads. There is mud all over the State, and we will never get the public mind in a better condition to call for public improvements.

One of the great objections is the increase of taxation. I think that we ought to start out with the idea, as a matter of fact, as a matter of policy, that there shall be no increase of taxation on farms. It is estimated now that we spend four millions of dollars annually in the shape of making roads. You give any intelligent engineer four millions of dollars to spend judiciously in making roads, and in a few years you will think you are in

another country. I do not think there is any necessity for increasing taxation one dollar.

It is just as much of a benefit to the cities to have first-class roads as it is for the farmers. It is as important to the Pennsylvania Railroad, as they find now by the limited amount of travel and business that they get at the way stations. They will find it would be to their interest, and I understand they are willing and ready to submit to taxation if necessary to procure good roads. I think if we start out to make a law it will be a law that shall be a perfect chain; no submission to any local dictation whatever.

A MEMBER: I have heard no reference to the old classification of roads. There is a difference in the old classification. There are State roads in Pennsylvania laid out as such.

T. P. ROBERTS: Not now. There were State roads.

A MEMBER: I suppose not since the change in the Constitution of 1874. I have not examined the subject, but we have turnpikes that were national roads, and we have State roads and we have township roads.

A. DEMPSTER: I never heard of such a classification. Now, as to the comparing of roads with railroads. There is no comparison between the running of a railroad and the making of a township road. If you were to take a turnpike and say how the officers of that company should be organized, as compared with a railroad company, there would be some comparison, but there is none in this thing. Mr. Kirk is entirely at fault, so far as our present proposed law is concerned, in saying the road is left to these three road directors, because it is not. It is left to them with the engineer, and the engineer is limited to getting the best gradient. He cannot do anything else. Then he must take the shortest line, and that with the least damage. How better can you put it than that; the best gradient, the shortest line and the least damage. After the location has been defined and they have passed to the opening of that road, it is put in such a way nobody can close it. If the people are not satisfied the matter of damages comes into court but the road goes on. You may just as well accept a state of facts. If you take away from the people who pay the taxes the say-so in the management of

their local affairs, you may just as well attempt to turn the American Government upside down, because you can't do it. There are no people, not even Mr. Kirk, who would submit to anything of that kind. And now, having accepted as a fact, this principle that is engrafted in every American heart, that he must have representation where there is taxation, we must elect good men as a safeguard. Good men should be elected. They must be freeholders, and must have been freeholders in the district for three years preceding. These men, with the engineer, have control of the purely township road, but when it comes to the main roads, the State roads, from one county to another, they are classified in our law as highways. They are under the control of the county engineer. He is made responsible for good work that shall be carried on, and all his assistants are responsible to him and dependent upon him. This makes him a head and responsible for all the actions of his assistants, and he makes them responsible for their portion of the work. They, the road directors, are elected independent of him, but the law gives him full control, absolute power, you may say, in the expenditure of money. You do not take away from them the semblance of authority in the matter in this way.

A. KIRK: If that is the case, where does his colleagues come in?

A. DEMPSTER: Now, Mr. Kirk, I put it to you fairly. If we were to pass such a law as you indicate, you would be about the first man to kick. There are no men who can go all over the State. You must concentrate and have local government. That was brought out at Harrisburg. It would never do to have the State take charge of the roads. You must localize them. If there was a State Superintendent or a State Engineer to take charge of the roads, what would it be? It would be worse than now, in a short time. There would be the cry of corruption, and probably, cause for it. We would not be able to stand it. That cannot be done. The best thing, in my opinion, is to get what can be gotten, as good, practical a law as we can; but so far as I know, and from the discussion I have heard on it, I do not see there is much improvement can be made in the law that was approved by you last March. There may be some little points that

would bear revision, but as a general line I do not think there can be much improvement on it.

J. H. HARLOW: Suppose that board and the engineer would be at loggerheads?

A. DEMPSTER: That might tie up the road, but the general thoroughfares are under the control of the county engineer, and they would not be affected.

A MEMBER: What provision is made for the division of funds between the county and the township roads? What portion of the funds, of the general funds, is to be applied to the township; what portion to the county roads?

A. DEMPSTER: This local board has power to assess what they want to spend on the local roads, and the county commissioners have power to assess for the highways. Then the treasurer is authorized to collect a certain amount of State tax to go into that highway fund, not into the road fund.

A MEMBER: Does that special tax go into the general county tax?

A. DEMPSTER: It goes into the road fund; the local road fund and the general road fund, and the State and county taxes go into the highway fund.

A MEMBER: When the farmer pays his taxes, does he know how much his road tax is?

A. DEMPSTER: Yes, sir; that is printed on the list.

A MEMBER: What provision is made for the taxes, the general county taxes?

A. DEMPSTER: Assessed as now. There will be no change in that respect.

T. H. JOHNSON: It seems to me that the vital points in this law rest simply upon these two features: First, in doing away with the labor tax and substituting a money tax for it, and then the other provision, which requires that a certain amount of that tax shall be expended in permanent improvements every year, and under the direction of an engineer. These two points must lead to good results. The other points are mere details.

A. KIRK: I rather think it will be necessary to have a road engineer, or whatever you may call him—a State engineer. If

every county is made independent of its neighbor, and has its own engineer—here is a road to be built from here to Butler—we will use that as an illustration. While that road is in Allegheny county, we will suppose it is in a tolerably fair location, but when it comes into Butler county, it runs through a district that they want changed for some cause or other, and they want to strike Allegheny county different from Allegheny county's engineer, who is to settle that point? It is not impossible to expect things of that kind. If we have a State engineer, he settles such matters.

A. DEMPSTER: Would you have a State engineer travelling all over the State locating roads?

A. KIRK: I would have more especially a State engineer to collect accounts and statistics of roads; to be a centre of information for every county engineer that wants it.

A. DEMPSTER: That is contemplated in the law.

T. P. ROBERTS: How is that 7 per cent. mentioned in the law expended?

A. DEMPSTER: It is put into the highway fund and expended by the county. Everything is done by the county and if there is a State officer he would be a head. The State Superintendent of Schools is something similar, and all the county engineers would report to the State Engineer, receiving general instructions from him so as to insure uniformity of action throughout the State.

A. WILKINS: If a dispute such as mentioned should occur, is there any settlement for it?

A. DEMPSTER: No, sir. There is no such provision. Such a case I think is purely hypothetical and imaginary.

M. J. BECKER: Among the fundamental principles of this government there is this general one which has been underlying all our institutions; namely, that the principle of self-government should be carried down to the minutest detail, and the pride of our institutions has been resting on that principle largely. And it would be somewhat difficult, as I can readily see, particularly among the rural population, to institute a measure which would deprive them of the exercise of that long cherished principle. At the same time it cannot be denied that with the changing circumstances and the rapid advancement of general civilization

throughout the world there is a tendency towards centralization in all governments.

The point that Mr. Dempster mentioned in his paper regarding the administration of affairs within the limits of the township and which was taken up by Mr. Kirk, strikes me as one that is entitled to some consideration. I can readily see that if we carry the administration into such close quarters and small subdivisions as townships that there would be a great source of trouble growing out of it, not only on account of the neighborhood considerations which Mr. Kirk mentioned, but the individual contests between two men occupying similar positions or the same positions in two adjoining townships. They might be perfectly honest and yet differ materially in their views as to how certain matters should be carried out. If there were a stubborn man in charge in one township, or one disposed to be ugly he might step you right in a mudhole while you might have good roads on either side for miles. Still these things are not much to be feared. It seems to me that the good common sense of the people will come to the rescue. I have seen that in my own experience, in cases that came under my personal observation, where streams forming the boundary lines between counties and States had to be bridged, and where conflicting views and varying interests were always adjusted satisfactorily to all concerned. I do not apprehend any serious trouble about that. The time for building what you might call trunk highways, running through the country for long distances, such as national roads, is past. Other means of communication have taken their places, and what is needed now is to establish short lines of communication between interior towns, roads leading to the depots of railways, harbors and steamboat landings. Things of that sort; that is all that is wanted, but they must be such as you can use. We would bring the control down practically to counties and townships and with the provisions of the law as I understand it there can be no very serious obstacle in the way of carrying out a series of improvements, progressive, as well as for the purpose of repairing and maintaining. Nevertheless I can see that some court of last resort, some place of appeal at the seat of the State government will be necessary to supervise the whole and

keep a fatherly eye over the administration of the local authorities. There might be cases where some appeal would have to be taken, just as in the case of the schools. It could be connected with some other office perhaps, but some place of last resort should be established.

Among the arguments that were heard in Harrisburg I have noticed several, and I was particularly struck with the remark made by some one, I do not now remember his name. After delivering a very fair argument in support of the subject, he wound up by saying, "Of course the railroads will oppose this thing."

Where the "of course" came in I cannot say, but it is illustrative of the generally prevailing superstition that a railroad opposes everything on general principles.

The remark which the chairman made regarding the improvement of roads near Philadelphia indicates that is not true. It would be absurd for railroads to oppose the building of good roads because it would actually be detrimental to their interests. If they are selfish they know what is best for them. They know a good thing when they see it. What is the use of having a railroad station if you cannot get to it. This statement is too absurd to require any controversy on my part. But while it is safe to say that railroad companies are in favor of good country roads, there are cases when they get more of this commodity than their proper share.

In Ohio, where they duly appreciate the necessity for good roads, they have adopted a somewhat different way for their introduction. They passed a bill called the free turnpike law, under which macadamized roads are built by a system of taxation on the surrounding and adjacent property. They take a map, and levy a tax on all property, say within a mile or a mile and a half of that proposed free turnpike, and the first thing the commissioners would do when they were appointed to locate a free turnpike was to look over the map and find where there was a railroad, and they would invariably locate that turnpike within the limits of that railroad's mile distance. Then they would tax that road for all there was in it. A railroad in Ohio, such a line as the Pan Handle for instance, is valued at $15,000 to $25,000

per mile. You take a rate of three cents per hundred and you see the railroads have built about all the roads in the State. That is an illustration somewhat the opposite of the argument of our friend at Harrisburg. They have done more in Ohio for roads than I hope they will ever be called upon to do in Pennsylvania.

The tendency that I mentioned towards centralization occurred to me just now as pretty clearly illustrated so far as railroads are concerned. Originally when they were built they were little neighborhood concerns built by the subscriptions of a few people. Their extent was limited. They have grown by aggregation, one line swallowing up another, until they have finally developed into large trunk lines, although they were not generally built for that purpose. This change in the direction of centralization is one of the causes which has made it necessary to establish an inter-state commerce commission.

If there is any provision in the law to establish in connection with it some supreme court at the seat of State government it will be a good thing. It ought to be provided for. I do not think the bill would be a good bill without it.

On motion, the Society adjourned about 10 P.M.

THOMAS P. ROBERTS,
Secretary pro tem.

MARCH 18TH, 1890.

Society met at 8 o'clock, P.M.

President Scaife in the chair.

Vice-President A. E. Hunt, Director M. J. Becker, and fifty members and visitors present.

The following applicants for membership were balloted for and elected: C. V. Kerr, S. L. Tone, J. A. Thorsell, Gustave Mueller, J. P. Edwards, E. G. Caughey and S. W. Black.

A. E. Hunt announced that the Iron and Steel Institute of Great Britain would sail from London about September 20th, the Institute of Mining Engineers meeting first week in October;

they will then start for Pittsburg to the International Meeting in this city.

Motion by A. E. Hunt that a committee of five be appointed by the president to co-operate with the American Institute of Mining Engineers in entertaining the visitors.

The following paper was then read by L. B. Stillwell:

PUBLIC SAFETY AND THE DISTRIBUTION OF LIGHT AND POWER BY ELECTRICITY.

To those interested in the problem of the economic utilization of electricity in America, the question of danger is the question of the hour. Not the only question, of course, nor even, perhaps, the greatest question; but, nevertheless, that question which stands out with special prominence and demands immediate solution. The perfecting of the almost innumerable details of dynamo construction, the designing of new and improved forms of indicating and measuring instruments, the improvement of the storage battery, the increase in the efficiency of incandescent lamps, the development of underground systems of conductors, the great possibility of transforming energy in the form of heat directly into energy in the form of electrification, without the intervention of the steam-engine and the dynamo; all these and others are, perhaps, problems of greater scientific interest, but the one practical question which everybody is just now asking, and which electricians must answer fully and satisfactorily is, can electricity be utilized without serious danger to life and property?

The causes which have contributed to bring this subject into special prominence are not difficult to analyze. The general facts at least are familiar to all. Within the last decade the electrical industries have taken their place among the great industries of the country. The telegraph and telephone are followed by the motor and the electric light. In the telegraph and telephone that property of electricity which especially appeals to the imagination is speed; in the light, and still more in the motor, we are impressed with the manifestation of power. In the telegraph circuit the energy is not great, in the telephone it is exceedingly little,

but in light and power circuits, hundreds and even thousands of horse-power are already employed, and it is but a question of time when even these figures shall be far exceeded.

The most recent statistics in my possession showing the extent of the use of this agent are those collected by the secretary of the National Electric Light Association, prior to the meeting of that organization in August, 1889. These statistics show, that at the time this convention was held, the number of arc lights in use in the United States was 237,017. The number of incandescent lamps was 2,704,768 (I presume this means 10 c. p. lamps). The number of street railroads operated by electricity was 109, comprising 575 miles of track and 936 motor cars. It was estimated that the capital invested in these industries amounted to $275,-000,000.

From these figures it may be roughly calculated, that in supplying these lights with current, and in operating these electric roads, a boiler and engine and dynamo capacity of 500,000 horse-power is required. We may not expect to employ such power as this without a certain amount of attendant risk. Man has never harnessed the great forces of nature without more or less difficulty and danger. The chances of accident are increased by the fact that the practical development of the science is so very recent. A large proportion of the men engaged in installing and operating apparatus are not thoroughly prepared for their work ; many practical problems remain unsolved, and as to the theoretical analysis of the subject, the greatest of our electricians confess that they do not know accurately what electricity is. A series of shocking accidents has startled the public, and has called attention to the possible dangers of this unseen and in some ways mysterious energy.

In this country where everybody reads the newspapers and keeps fairly well posted as to progress, and where especial interest always attaches to the newest thing, a certain amount of information concerning the subject, for the most part of a vague and uncertain, and consequently credulous character exists. Anything electrical is of interest. Electricity in the eyes of the public is the symbol of the marvellous. Moreover, its laws are more or less mysterious, and nobody is able to say just what it may or may not accom-

plish; consequently, since we are fond of predicting great things, everybody has been telling his neighbor what he believes this new thing is going to do, and in general, the less a man knows of the subject the more marvellous are his predictions. The development of the science has been so wonderfully rapid, that even those actually engaged in the business are unable to keep themselves well-informed concerning all of its already numerous branches. Electricians themselves have been compelled to specialize, and in view of this fact, it is not strange that the interest of the public is as yet largely qualified by ignorance. In no other branch of science is this interest so general. It is therefore not surprising that the occurrence in rapid succession of some half dozen fatal accidents in one of our largest cities, has attracted universal attention, and has created in the public mind a distrust closely akin to panic.

Newspapers, ever ready for sensation, have seized upon the opportunity and have published harrowing accounts of the fatalities, having sometimes a foundation of fact, and in many cases, a considerable superstructure of fancy. Ridiculous as are many of these newspaper accounts, and unfounded as is the alarm of the public, the agitation of this subject is nevertheless timely, and the effect will undoubtedly be beneficial to the public in general, and to those directly interested in electrical work in particular. Fierce competition between electric lighting corporations, existing while this rapid development of the business during the past ten years has been going on, has resulted too often in careless and inefficient work. The great desire on the part of local companies investing in apparatus to realize the largest possible profit upon their investment, has, in many cases, prevented proper installation. The manufacturing companies have not always insisted upon careful running of circuits and use of safety devices. In their eagerness to close contracts those installing plants have often reduced their estimates at the price of reducing their factor of safety in operation. It is therefore, fortunate for the general interests of the business that a halt has been called.

In this paper I shall attempt a brief description of each of the methods of distribution commonly used, dealing only with the

more important features of each and omitting so far as possible minor details of construction and operation not essential to a general understanding of the subject. I shall endeavor to treat the subject from a popular rather than a technical standpoint. I shall point out some of the risks peculiar to each system and indicate some of those precautions by the observance of which these risks may be in greater or less degree obviated. For convenience and clearness I shall make the following classification :

First. Methods of supply in which there is direct electrical connection between the generator and the lamp, motor or other translating device.

Second. Methods of supply in which the energy from the dynamo is not delivered directly to the translating device, being modified in its characteristics of potential and quantity by the interposition of the transformer or converter.

In each of these classes we have three sub-classes, namely :

First, series ; second, parallel or multiple arc ; third, multiple series.

This classification in sub-classes depends upon the methods of running the circuits.

It will be most convenient to refer first to certain elementary definitions and laws, then to consider each of the sub-classes named, and finally to point out what modifications result in each of these sub-classes when the transformer is used.

An electrical circuit may be said to consist of a generator of electromotive force and one or more paths or circuits connecting the terminals of the generator. A dynamo without any paths or circuits connecting the terminals is simply a generator of electromotive force. When we provide circuits leading from one terminal to the other, current begins to flow, as we commonly say. This idea of the flowing of current is of course simply a fiction used for the purpose of lending definiteness to our conception and enabling us to speak intelligibly without going back to first principles. It is certain, of course, that nothing material does flow, nevertheless, the phenomena actually occurring have a general resemblance to the flowing of water, and the analogy is extremely useful. It is, therefore, common to speak of the current in an electric circuit as

flowing, and it is generally assumed to flow from the positive to the negative terminal of the generator.

As above stated a dynamo having no path or circuit connecting its terminals generates simply electromotive force. No current flows and the energy in the circuit is zero. The instant a path is provided between the positive and negative terminals of the machine, however, current begins to flow, and at that instant energy appears in the circuit.

Energy, then, is not represented by electromotive force, alone, nor is it represented by current alone, but it is represented by the product of these two factors. This is a fundamental statement and one that becomes of great importance as we proceed to consider the problem of the distribution of electrical energy.

To make this clear it is sufficient to suggest the common illustration of the analogy of a circuit carrying current and a pipe conveying water. Electromotive force in the former finds its analogue in the pressure or head of the latter. The current in the electrical circuit is not accurately represented by the quantity of water flowing through the pipe, since our definition of a quantity of water flowing, as so many gallons per minute, or per second, combines the idea of rate of flow with the idea of time. If, however, in the case of the electrical circuit we substitute for current quantity, by multiplying current by time we have a strict analogy between quantity of electricity and quantity of water.

The energy represented by water flowing from a pipe in a second is proportional to the product of the head or pressure and the quantity of water which flows in that second. In like manner the energy in the electric circuit in a second is equal to the product of the electromotive force and the quantity of current. It is evident that since in each of these cases the energy is represented by the product of two factors, its amount may be varied by varying either of the factors. In hydraulics a certain definite amount of energy may be represented by a head of 746 feet and a flow of one gallon per second, or it may be represented by a head of one foot and a flow of 746 gallons per second. In electricity, similarly, a horse power may be represented by an electromotive force of 746 volts and a current of one ampere, or it may be represented

by an electromotive force of one volt and a current of 746 amperes. That we may understand the bearing of this fact upon the problem of electrical distribution it is necessary to refer to another fundamental law, namely, that which expresses the loss of energy in a circuit. The law is, that the loss of energy in any circuit conveying electricity is proportional to the square of the current multiplied by the resistance of the circuit.

For a circuit having a certain resistance, then, we quadruple the loss every time we double the current. That loss does not depend upon the electromotive force employed. It varies only with the current.

Now suppose that it is necessary to supply energy to two motors placed in independent circuits, and suppose that the resistance of each circuit outside the motor is equal to 1 ohm. Assume that the energy to be delivered to each is equivalent to 1 horse-power, that is, to 746 watts. To the first motor, let this amount of energy be supplied by delivering 10 amperes at a pressure of 74.6 volts. To the second, let 1 ampere be supplied at a pressure of 746 volts. Precisely the same amount of energy is delivered in the two cases, and if the motors used be properly constructed the results, as far as the motors are concerned, should be equally satisfactory. Now, consider the loss in the circuits outside the motors. In the first case, 10 amperes were forced through a resistance of 1 ohm. The loss in energy is found by multiplying the square of the current by the resistance, and is equal to 100 watts. In the second case, the loss estimated by similar calculation is 1 watt. Comparison of these two cases shows that by increasing the electromotive force ten-fold, the loss in the conducting circuits, which is, of course, simply waste of energy, is in the second case reduced to 1 per cent. of its value in the first case. It appears from this, that as far as loss of energy due to the resistance of conductors between the generator and the motor or other translating device is concerned, it is very expensive to carry current, but costs nothing to convey pressure or potential.

The law may be stated as follows:

To convey a given amount of energy, a given distance with a given percentage of loss in the conductors, the resistance of the

circuit must vary inversely as the square of the electromotive force employed. Now the resistance of the conductor varies inversely with its cross-section, and for a given length the cost of conductor will vary directly with its cross-section. Therefore we may put the law above stated into an expression involving dollars and cents, by saying that in conveying a given amount of energy a given distance with a given percentage of loss in the conductors, the cost of these conductors will vary inversely as the square of the electromotive force employed. In distributing energy at 200 volts, the cost of copper in the circuits is but one-fourth the cost in distributing energy at 100 volts; at 500 volts the cost is but one twenty-fifth, and at 1000 volts, one one-hundredth as much as in distributing at 100 volts. In the illustration of the two one-horse-power motors above referred to, the cost of conductors for the second is 1 per cent. of the cost of conductors for the first.

In the above statement and illustrations of the law governing the relation of electromotive force employed and the cost of conductors, no account is taken of insulation. The statements made are based simply upon the cost of bare copper. In practice, the commercial application of this law is limited by the fact that almost any pressure calls for some insulation, and the higher the pressure the better the quality and the greater the cost of such insulation. The law governing variation in the cost of insulation as potential is increased, therefore opposes, to a greater or less extent, the law governing the variation in the investments for copper, as above stated; nevertheless, it is true, that economy in investment for conductors imperatively demands high potential. Bearing this in mind, and recalling the fact that in distributing power we may vary either the potential or the current, it is not difficult to understand why the development of electrical apparatus has been along two opposite lines. Dynamos may be designed to deliver either a constant potential and a variable current or a constant current and a variable potential. Corresponding with these two classes of machines, we have in the systems of conductors distributing energy also two classes, namely: first, Series circuits, and second, Parallel or Multiple Arc circuits. We have also systems involving combinations of the series and parallel methods.

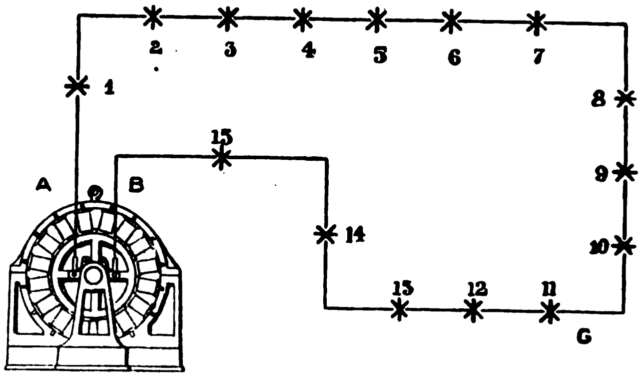
The series system is usually adopted in supplying arc-light circuits. In this system, if the circuit be perfectly insulated, there is but one path for the current from the positive to the negative terminal of the dynamo. That path leads through each of the lamps placed one after another in the circuit, that is, from the positive terminal of the dynamo the current passes along the conductor to the first lamp; passing through the mechanism of this lamp and forcing its way across the small clearance between the two carbons, at which point the arc is formed and the light is developed, it leaves this lamp and traverses another section of conductor to the second lamp in the series. Passing through the second lamp in the same manner, it traverses another section of conductor to the third lamp and so on, finally returning to the negative terminal of the dynamo. The difference of potential between the terminals of each lamp, that is, between the point where the current enters the lamp and the point where it leaves, is about 50 volts; therefore, at each lamp a drop of 50 volts occurs in the electrical pressure. The strength of the current measured at any two points in the circuit is the same, and is equal to about 10 amperes. The difference of potential delivered by the machine is varied in such a way as to be proportional at all times to the number of lamps burning. If ten lamps are burning, the difference of potential at the terminals of the dynamo is 500 volts. If 20 lamps are burning, the difference of potential at the terminals of the dynamo is 1000 volts. This arrangement is illustrated in Fig. 1, which shows 15 lamps in the circuit.

Let the wire A be connected to the positive terminal of the dynamo, and the wire B to the negative terminal. A current of 10 amperes is assumed to flow through the lamps in their order, that is, through 1, 2, 3, etc., returning after traversing all of the lamps to the negative terminal by way of the wire B. If we measure the difference of potential existing between B and the wire A at the positive terminal of the dynamo, we shall find 750 volts. Measuring the difference of potential between B and the conductor between the first and second lamp, we shall find 700 volts; measuring the difference of potential between B and the conductor between the second and third lamp, we shall find 650

volts, and so on, the difference of potential decreasing 50 volts as each lamp in the circuit is passed. In such a circuit as this the number of lamps does not usually exceed 60, which corresponds with a difference of potential of about 3000 volts.

In multiple arc or parallel distribution, there are two or more paths for the current from the positive to the negative terminal of the dynamo. This arrangement is illustrated in Fig. 2. As is seen upon inspection of this figure the circuits bear a general resemblance to a ladder, the main conductors being represented by the frame of the ladder, while the short conductors in which are

FIG. 1.



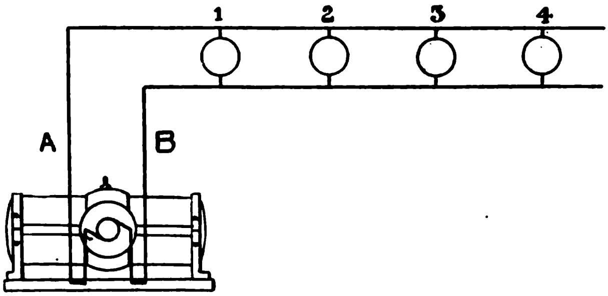
placed the lamps, or motors are represented by the rounds. In this system the dynamo delivers a constant potential and a variable current. A constant difference of potential being maintained between the two main wires of the circuit the current will of course vary as the lamps are turned on or off. Referring to the figure the large wires *A* and *B* represent respectively the two sides of the main circuit. Between these main wires incandescent lamps are shown at 1, 2, 3, etc. The dynamo is so constructed as to automatically maintain a constant difference of potential between the mains *A* and *B*.

If all the lamps are turned off the entire circuit is interrupted and no current flows. If the lamp at 1 be turned on, the others being left as before, a certain amount of current sufficient to supply

this lamp will flow along the conductor *A*, through the lamp at 1 and back to the dynamo by way of the conductor *B*. The amount of current which this lamp will take is of course determined by its resistance and the difference of potential applied to its terminals. Now suppose that the lamp at 2 be turned on. Twice as much current will flow in the conductors *A* and *B* as before, but the first lamp will be in no way affected. In like manner the lamps at 3, 4, etc., may be turned on or off, that is, they may be cut into the circuit or cut out without affecting their neighbors.

A moment's thought reveals the reason underlying the universal practice of employing parallel systems of distribution for interior lighting. Each lamp must be absolutely independent so

FIG. 2.



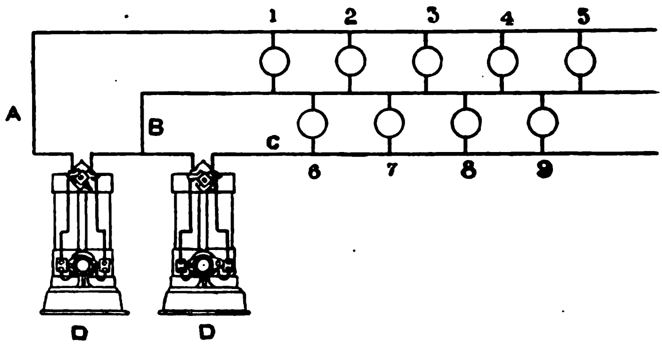
that it may be turned on or off as needed without affecting the others. Arrangements accomplishing this have been devised for series systems and are commonly used on arc-light circuits, but these devices involve an amount of additional mechanism, an uncertainty in their action and in many cases a loss of energy which are not allowable in a commercially operative system of inside lighting.

A modification of the parallel system is effected by substituting the earth or ground return for one of the main metallic conductors, that is, for one side of the frame of the ladder. This is the arrangement usually employed in the street car service already so extensively adopted in this country. An approximately constant

difference of potential between the overhead conductor and the earth is maintained, and the motors propelling the cars are connected in parallel to the circuit thus formed. Commonly the rails are used for the return circuit, special precautions being observed to insure metallic connection between adjacent rails, but of course this side of the circuit is very thoroughly grounded and is properly described as an earth return. The difference of potential usually employed in these street railway systems in America is about 500 volts.

Multiple series systems are combinations of the series and the parallel systems of distribution. A notable illustration is found

FIG. 3.



in the three-wire system extensively used in this country by the Edison Company, and is illustrated in Fig. 3. In this arrangement two dynamos, D and D', are so connected as to form an electrical unit, that is, they must be run together and constitute practically one machine. Three conductors A, B, and C, distinguished respectively, as the positive wire, the balancing wire, and the negative wire, are used. As shown in the figure the positive terminal of the dynamo D is connected to the positive wire A. The negative terminal of this dynamo and the positive terminal of D' are connected to the balancing wire B, and the negative terminal of the dynamo D' is connected with the negative wire of the system. Lamps are shown at 1, 2, 3, etc.

If the number of lamps burning in each of the two branches of the circuit, that is, between *A* and *B*, and between *B* and *C* is the same, no current flows in that part of the balancing wire which lies between the lamp 1 and the dynamos. The current leaving the positive terminal of the dynamo *D* passes along the conductor *A* through the lamps 1, 2, 3, etc., through those short portions of the conductor *B* lying between the terminals of these lamps and those of the other branch of the circuit, then through the lamps 6, 7, 8, etc., then back by way of the conductor *C* to the negative terminal of the dynamo *D′*.

Now suppose that five lamps connected between the conductors *A*, *B*, and *C* are burning, while between the conductors *B* and *C*, but four lamps are in circuit. Current sufficient to supply five lamps will flow along the positive wire *A* and through the five lamps to the balancing wire *B*. Four-fifths of this current will flow thence through the lamps between *B* and *C* to the negative wire *C*, but the balance of the current, that which has flowed through the fifth lamp in the upper branch of the system, will return to the dynamos by way of the balancing wire B.

If five lamps were burning between *B* and *C* while but four lamps were in circuit between *A* and *B*, the current in *B* would flow away from the dynamo through the fifth lamp and return to the negative terminal of the dynamo *D′* by way of the negative wire *C*. This, then, illustrates the function of the balancing wire. It is not needed so long as equal numbers of lamps are burning in the two branches of the circuit, but when the number burning in one branch exceeds the number in circuit in the other branch the balancing wire carries a current proportional to the difference in the number of lamps in circuit in the two branches.

The purpose of this arrangement is to effect economy in copper. As we have seen, in lighting a given number of lamps located at a given distance from the dynamo with a certain percentage of loss of energy in the conductors, if 200 volts be used, but one-fourth the amount of copper is needed that would be needed were the potential limited to 100 volts. It has been found that the highest pressure that it is practicable to apply to the terminals of a single filament incandescent lamp is about 110 volts. Experience seems

to have established this limit for the present. For two-wire systems of distribution in which the lamps are electrically connected with the dynamo, therefore, common practice has fixed the limiting pressure at this figure. The three-wire system doubles this pressure, as measured between the outside, that is, between the positive and negative wires of the system. Doubling the pressure, if no third wire were necessary, would, as before stated, divide the necessary copper investment by four, but since the balancing wire is needed to take care of the system in case the number of lamps burning in one branch exceeds the number burning in the other, the cost of copper for a three-wire system as described, assuming that the balancing wire is of the same cross-section as each of the other wires, is to the cost of the two-wire system as 3 is to 8.

Other multiple series systems, known as four-wire and five-wire systems, have been devised. These are similar in principle to the three-wire system already described, and as their commercial adoption up to date is very limited no further reference to them need here be made.

This completes our discussion of the three sub-classes in methods of distribution. As before stated this classification depends upon the methods of running the circuit, and each of these three sub-classes is applicable to each of two great methods of supply. The first of these two great classes is that method in which there is direct electrical connection between the generator and the lamp or motor; the second is that method of supply in which the energy from the dynamo is not delivered directly to the lamp or motor, being modified in its characteristics of potential and quantity by the interposition of the transformer or converter. In the first of these classes the transformer is absent, in the second it is present.

A few words in explanation of the transformer. The armature of every dynamo delivers an alternating current, that is, a current whose direction considered with reference to any wire in the armature is reversed many times per minute. The commutator is a device to which the wires of the armature are connected and. upon which rest metallic or carbon brushes which are joined with the external circuit. This commutator is usually placed upon the

armature shaft and is so arranged as to collect the impulses of current delivered by the armature and deliver them to the external circuit rectified, that is, all flowing in one direction. Such a current as now flows in the external circuit is commonly called a direct or continuous current.

If, instead of using a commutator we simply mount upon the shaft two metallic rings connected with the ends of the armature circuit the alternating current delivered by the armature is collected and is delivered to the external circuit as alternating current. In our college laboratories many of you have seen an experiment something like the following:

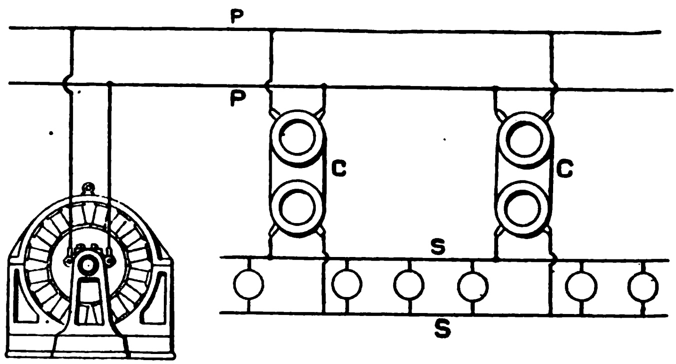
Two wires are placed in close proximity to each other throughout a considerable portion of their length. One of these wires is connected with a battery or other source of electric energy. The other wire is connected to the terminals of a galvanometer or other indicating instrument. When the circuit of the first wire is made or broken, the galvanometer shows that a current flows momentarily in the second wire. This is an ordinary illustration of the phenomenon of induction.

Any increase or decrease in the strength of the current flowing in the first wire causes current to flow in the second wire, the direction of the current in the second wire being always opposite to the direction of the current in the first wire. The two wires so arranged constitute a transformer or converter, though a very inefficient one. If, however, we take two long wires and wind them into coils, then place these coils near together and surround them with iron, we get a transformer which is able to transfer a very large proportion of the energy in the first wire to the second wire. This is the arrangement ordinarily adopted in commercial transformers. The primary coil is connected to the terminals of the dynamo, and receives, of course, an alternating current. The rapid reversals of this current in the primary cause powerful inductive actions upon the secondary, and an amount of energy almost equal to that in the primary wire appears in the secondary wire.

There is no electrical connection between the primary and secondary coils. The energy in the primary circuit develops mag-

netism in the iron of the converter. This magnetism, changing in sign and value very rapidly, induces an electromotive force in the secondary. The relation of electromotive force in the two coils will depend upon their respective lengths. If the primary and secondary are of the same length and we deliver to the primary an alternating difference of potential of 1000 volts, we get at the terminals of the secondary a difference of potential of 1000 volts, but if the primary is twenty times as long as the secondary and we deliver to it, as before, a difference of potential of 1000 volts, the difference of potential at the secondary terminals is 50 volts. When this circuit is closed through 20 50-volt lamps, a current of 20 amperes will flow at a pressure of 50 volts. This last arrangement is that usually adopted in incandescent lighting by

FIG. 4.



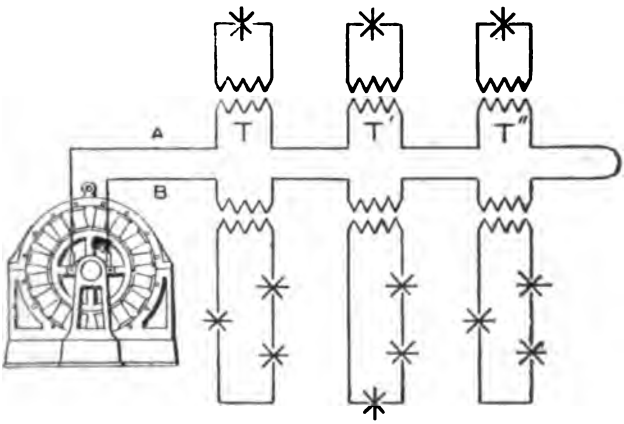
transformer systems in this country. The difference of potential in the primary circuit is twenty times as high as the difference of potential in the secondary circuits, while the current in the secondary circuit is twenty times as great as the current in the primary.

The object of this arrangement is of course economy in copper. Incidentally other advantages are obtained; first, entire separation of the inside circuits from the street mains; and second, ability to use what are commonly called low-voltage lamps, which are more efficient and durable than lamps requiring high pressures.

While the transformer system is equally applicable to series, parallel or multiple series, arrangements of circuits, its marked development thus far has been in connection with incandescent lighting and consequently with the parallel or multiple arc system of distribution. The ordinary arrangement of circuits is shown in Fig. 4. The wires *P* and *P* are supplied with alternating current from the dynamo. The difference of potential usually employed is 1000 volts. The secondary circuits of the transformers are connected to the wires *S* and *S* forming the mains of the secondary circuit. The difference of potential between these mains is 50 volts, and the incandescent lamps are connected in parallel to this circuit.

Within the last six months a series system employing transformers has appeared. In this, as in other series systems, the current is kept constant while the potential is varied with the number of lamps in use. This arrangement is illustrated in Fig. 5. The current leaving the positive terminal of the dynamo traverses the conductor *A* to the first transformer *T;* passing

FIG. 5.



through the primary coil of this transformer it traverses another section of conductor to the second transformer *T′*, and so on through the primaries of all the transformers in the circuit,

finally returning to the negative terminal of the dynamo by way of the wire *B*. The lamps are connected in the secondaries of these transformers. In some cases but one lamp is supplied by a transformer, in other cases three or five lamps are supplied. In this arrangement there is no electrical connection between the lamps and the dynamo. Perhaps the most striking feature of this system is the fact that the difference of potential in the circuit is not equal to fifty times the number of lamps, as is the case in direct supply. Without transformers the number of lamps that may be run in a series system is limited to about 60; with transformers a much greater number may be used without increasing the pressure in the line.

And now, where does the element of danger appear in these systems? Danger to life from the direct physiological action of energy in electric circuits can exist only in connection with circuits conveying currents of high potential. Anything that threatens property by causing fire, in a secondary sense, also threatens life, but, as far as danger to life from an accidental electric shock is concerned, it may be fairly said that low potentials are perfectly safe. But what is low potential and what is high potential?

It is impossible to draw a line through a certain point in a scale of ascending potentials and say that below this point no danger exists while above it all potentials are dangerous. Suppose that such a line be drawn at 300 volts. It is evident that there is no appreciable difference between the conditions existing in a circuit carrying 299 volts and another circuit carrying 301 volts, and it would be absurd to say that the former is safe while the latter is dangerous. Such a line of demarcation scientifically means nothing, nevertheless, for purposes of classification and to facilitate the drawing up of proper rules governing line construction and the general installation of plants, such a rule may be extremely useful.

It is not probable that electricians will ever agree as to where such a line as this may properly be drawn. Experiments of scientific value that might throw light upon the physiological effects of shocks from dynamo circuits are lacking. The best that can be done is to infer from the results of shocks accidentally

taken what potentials may, under certain circumstances, prove dangerous, to study as carefully as may be the conditions under which these accidents have occurred, and to determine so far as possible what precautions would have prevented their occurrence.

But inference from these cases of accidental contact with the circuits is very difficult. Testimony concerning the conditions under which the accident occurred is generally uncertain and often conflicting. In many cases, even the results are disputed, and the interests of the companies concerned or of those whose carelessness or ignorance may have caused the accident, sometimes result in concealment or obliteration of evidence that might perhaps have scientific value.

The results consequent upon a contact with high potential circuits are very largely dependent upon the manner in which contact is made. Every man carries around with him a certain amount of protection against the action of such a circuit. I refer of course to the resistance of the body. Here again we have a quantity that is very difficult to define. You will find printed statements of the resistance of a man's body from hand to hand, and these statements will vary all the way from 1800 to 50,000 ohms, and possibly between even wider limits. This wide variation in the results of measurements is largely if not entirely due to the fact that different methods of introducing the body into the circuit have been employed. In some cases the fingers have grasped metal contacts, and in others the hands have been immersed in solutions of high conductivity. The larger the surface in contact with the circuit the lower the resistance, and consequently since the resistance of the human body is very largely in the cuticle of the skin, any method that increases the area in actual contact with the circuit greatly diminishes the resistance of the body. It is not difficult to understand that a man firmly grasping the terminals of a dynamo may be killed by a pressure that would not seriously affect him had he simply touched the circuit with the tips of his fingers.

Last year the secretary of the National Electric Light Association instituted an inquiry into the subject of accidental contacts with high potential circuits. Letters were addressed to those

supposed to be familiar with the circumstances and results in a large number of cases, and many replies were received from men who had taken shocks, or, in those cases in which the accidents had proved fatal, from others who had investigated the circumstances.

The replies are interesting as showing the manner in which accidental shocks are ordinarily received, and they also illustrate the fact that a shock from a relatively low potential may in some cases result fatally, while shocks from much greater potentials often produce no serious effect.

From an abstract of the letters referred to, I note that of 36 cases of shock from arc-light circuits, 18 were from hand to hand. None of these shocks were fatal. 14 were from hand to feet, of which 3 were fatal. One shock of 1250 volts from forehead to right hand was not fatal. One of 2250 volts from elbow to feet was not fatal. One shock of 3000 volts from hand to opposite knee was fatal. One shock of 1500 volts from hand to side over heart was fatal. The 18 non-fatal shocks received from hand to hand were from circuits carrying potentials ranging from 1000 to 2500 volts. The man receiving the current between hand and side over heart was killed by 1500 volts. 19 men receiving shocks from higher potentials from hand to hand or from hand to feet were not injured.

It is evident that a great deal will depend upon the manner in which contact is made with the circuit.

Another influence modifying results in these cases is found in differences in constitution or strength of those receiving the shock. A shock that would not seriously affect a man may seriously or fatally injure a child. It is also probable that differences in temperament or nervous organization tend to vary the results. The entire subject of the physiological effect of shock is a very difficult one, and thus far the amount of reliable and scientifically valuable data is extremely limited.

Practically, however, it is not difficult to say which of the several systems in common commercial use are dangerous, and which are not. It is not a question of absolute but of comparative danger. No one will claim that the potential of 100 volts

which is extensively used in lighting large buildings by isolated plants can under ordinary conditions cause fatal shock. Probably few will deny that the 3000 volts of an arc-light circuit are dangerous, and should be surrounded with special precautions. Between these limits lie systems employing 300, 500, 1000 and 2000 volts, and other potentials.

A few moments must suffice to point out where the element of danger exists in each of the great commercial systems of distribution. This danger is of two kinds: first, danger of physiological shock, and second, danger of causing fires.

A person receives a shock by coming in contact with an electric circuit in such a way as to cause a part of the current to pass through his body. This may be done in either of two ways: First, by putting the person in contact with two points in a circuit, these points being charged with different potentials, as, for example, when a man grasps the positive terminal of a dynamo with one hand and the negative terminal with the other. Of, course, a contact of this description can be made accidentally by none except those engaged in operating a plant, or in doing construction work upon the circuits. If lines be properly insulated, and dynamos and other station apparatus reasonably well protected, the chance of accidents of this description, even to employees, is extremely remote. Another way in which a person may become connected into the circuit results from what is technically known as a ground.

In describing the series system, I have said that in such a system, if the circuit be properly insulated, there is but one path for the current from the positive to the negative terminal of the dynamo. But absolutely perfect insulation is unknown. We must remember that at every point in a circuit conveying electricity a certain potential or electrical pressure exists. Between that point and every other point in the circuit which is at a different potential, there exists what may be called a state of strain tending to force the current from the point of higher to the point of lower potential. To prevent this the circuit must be thoroughly insulated, that is, it must be surrounded with some element or substance offering a high resistance to the passage of the electric current.

Referring again to Fig. 1, suppose that the wire at G is not so insulated, and suppose that another wire falls over the circuit at this point in such a way as to connect it with the earth. If the circuit between G and the dynamo is perfectly insulated, no current will flow. But suppose that while the circuit is grounded at G, a man comes in contact with an exposed part of the circuit in the lamp 1. Current will pass through him to the ground, thence to the wire which has fallen across the circuit, and thence back to the circuit at G. The shock will be proportional to the number of lamps between the point where he has made contact with the circuit and the point where a ground exists. In this case it will be due to a potential of about 500 volts.

If, instead of touching the circuit at 1, a man makes a contact between the lamp 15 and the dynamo, the shock which he will receive will be due to a potential of 250 volts. The chance of accident to the public resulting from grounded circuits is greater than the chance of accident resulting from actual contact with two points in the metallic circuit, but you will note that two things must happen before even such an accident as this can occur. First, the circuit must be grounded; and second, the man must come in contact with another point in the circuit. Instead of an actual metallic connection to earth, such as I have assumed, a considerable number of points of low resistance in the insulation will produce an equivalent condition of affairs.

Evidently if the circuit be so constructed and maintained as to avoid a ground, no such danger can exist. The first precautions that should be observed relate, then, to the construction of the circuit, and, in the case of aerial conductors, at least, they involve both mechanical and electrical features. In the first place, due regard should be had to such mechanical considerations as govern the construction of a bridge. The conductor should be so securely supported as to make sure that it will not break and fall into the street. The supports should be properly spaced, and should be well stayed against forces due to wind-pressure, unequal lengths of span or change in the direction of the conductors. In calculating the mechanical strains upon a suspended conductor, a large factor of safety should be allowed. In the second place the conductor,

if high potential is employed, should be thoroughly insulated with an efficient and durable material, except in the case of long distance transmission of power across the country, when in certain cases the insulation even of high potential lines may be dispensed with.

The electrical engineer has a great advantage over the mechanical engineer in the use of safety devices. A boiler may develop a weak point without giving any external sign of the coming explosion, but the electric circuit generally gives warning of the deterioration of its insulation. Even in those cases where a circuit is suddenly grounded through accident to the insulation, those in charge of the installation may, if they choose, be promptly informed of the occurrence, and they will, in nearly every case that can be imagined, have abundant time to repair the damage before any serious consequences can result.

In the case of the parallel systems of distribution, and in the case of multiple series systems as well, the conditions under which a shock may be obtained are very similar to those described in the case of the series system. One difference, however, is, that in case one side of the circuit be grounded, contact with the other side of the circuit, at any point, will result in a shock due to the full difference of potential of the circuit. As above shown, a shock resulting in this way from contact with the series circuit may be due to an extremely small or to a very great difference of potential, depending upon the resistance of the circuit between the ground and the point of accidental contact. But not so in the parallel system. Here, if one side be grounded, the full difference of potential supplied by the dynamo will exist between the other side of the circuit and the earth.

In the case of the single overhead conductor, extensively used in street-car service in this country, one side of the circuit, as has been said, is permanently grounded. The difference of potential existing between the overhead conductor and the earth in this system is usually about 500 volts. Contact with any point on the overhead conductor, unless the person making contact is insulated from the earth, will result in a shock due to 500 volts. In the case of these conductors, then, since no protection is afforded

by insulation of the other side of the circuit, it is especially important that the overhead wire be kept well out of reach, and so guarded that no other wires can possibly fall across it. In this country, telephone circuits ordinarily use the earth return, consequently, the contact of a telephone wire with the overhead conductor in such a street railway system, will, unless special precautions be taken, at least result in burning out telephones, and may cause serious shocks. It should not be difficult, however, to adopt such safety devices as would result in opening the circuit of any telephone line that may come in contact with the overhead conductor.

As to the high potential alternating-current systems of distribution the primary wires, that is, those wires which are charged with the high potential, are confined to the streets where the lines should be constructed in accordance with sound mechanical principles. They should be kept far out of reach of the public. They should be kept thoroughly insulated throughout their entire length with a satisfactory insulating material. The house-circuits are of low potential, 50 volts, and are entirely separated from the high potential of the primary circuits. Under but one combination of conditions can the primary potential enter the house-circuits. Those conditions are: the breaking down of the insulation between the primary and secondary coils, a ground on the street circuit, and a contact with the secondary circuit by a person making at the time of touching the circuit a good earth-connection. This chance is extremely remote. If not absolutely zero it is certain that proper precautions will make it a vanishing quantity.

If it be desirable, however, even this possibility of accident may be removed by any one of several safety devices. The secondary circuit may be grounded or the secondary coil may be surrounded by a metallic sheath connected to the earth, or other plans may be adopted.

Fires may be caused by electric circuits in various ways. The more common are two: *First,* suppose that we have two wires with a certain difference of potential existing between them, strung along the surface of a wooden partition or perhaps in a moulding. Suppose that in some way the wooden partition or moulding be-

comes wet. Unless waterproof insulation be used the moist surface of the board will form a more or less efficient conductor and current will flow across from the positive to the negative wire. The current forcing its way along the surface of the board develops heat. The board becomes charred and after a time perhaps we have a small blaze, which may become a large one. The danger is of course greater in the case of a high potential than in the case of a low potential circuit.

Second. A contact becomes overheated by an excess of current. Suppose that we have a fuse block or branch block in which the metallic contacts are not sufficiently heavy to carry the current, and suppose that the metallic contacts are mounted upon wood. The metal becoming excessively heated by the passage of a current too large for it begins to char the wood. The chances are that as the wood is charred and worn away, the resistance of the contact at this point in the circuit will increase, the heating effect will become still greater and perhaps sufficient heat will be developed to cause a fire.

Danger in this direction is greater in the case of circuits carrying large currents. You will remember that for a given amount of energy we may have a high potential with a small current, or we may have a low potential with a large current. It appears that a high potential tends to cause fires in one way while a large current involves a corresponding risk, arising in a slightly different manner.

A moment's thought demonstrates that neither of these dangers can exist where proper materials are used and where a reasonable amount of common sense is displayed. High potential circuits should not be allowed to lie against the surface of a wooden partition or floor, and cut-out blocks should be of porcelain or other non-inflammable substance and not of wood.

The one sufficient answer to all that may be said concerning the danger of electric circuits is that with proper construction this danger, although it cannot be reduced absolutely to zero, can be made very small. As far as the general public is concerned the element of danger is far less than is attendant upon the use of gas and steam. As to the risk incurred by the attendants of the gen-

erating station or those who are employed in maintaining the circuits, even that may be made slight. Pre-supposing a fair amount of intelligence and care on the part of those who do this work that risk will almost disappear.

The present agitation of this subject will undoubtedly tend to greater care in the construction and operation of plants. A certain amount of supervision in the way of general regulation imposed by the State, and intelligently directed by proper State authorities would meet the approval of all responsible companies engaged in the electrical industries. Whether or not the time is ripe for such regulation and supervision I will not presume to say. One thing is certain, that is, such regulation should aim to improve apparatus and to reduce to the farthest possible degree the risk necessarily attendant upon the utilization of large power. Whether directed by individuals, or companies, or the State, its purpose should be to secure proper construction, the use of proper materials and the exercise of proper supervision in the operation of plants. Interested parties in one, or two States have already attempted to secure legislation prohibiting potentials in excess of a certain value. To adopt such restrictions would be to cripple in infancy that industry which already promises to be the giant of this age. It would be exactly on a par with the statute that should decree that no buildings of more than one story in height should be built, for the reason that architects sometimes make mistakes and contractors occasionally use poor material. But there is little chance that such legislation will be adopted in any of our States. The people are interested in the development of this great science which has already done so much for their convenience and comfort, and which promises such wonderful results in the future.

Discussion.

George H. Payne: I am sorry Mr. Stillwell said nothing about underground electricity. That is one of the additional safeguards.

B. Speer: I should like to ask one question about something you referred to here with reference to the potential at the terminals of such a converter as you have described, which is supplying

three lamps. What would be the difference of potential at the two terminals of this converter?

L. B. STILLWELL: The difference of potential would be 50 volts, with a current of 30 amperes.

B. SPEER: On the same circuit?

L. B. STILLWELL: Exactly.

B. SPEER: Then in your diagram these are not meant to be the same circuit?

L. B. STILLWELL: This diagram, marked Fig. 5, represents one circuit.

B. SPEER: The same circuit cannot, of course, carry a circuit of 10 amperes and 30 amperes.

L. B. STILLWELL: The function of the one-arc light converter is in connection with these circuits. In some cases inside, and street lamps are supplied from the same circuits, the converter being used in the case of inside lights only.

B. SPEER: Do you make a converter which will supply a lamp on the same circuit as the single lamp?

L. B. STILLWELL: Yes. But this kind of a system is designed for use especially in large cities where the object is to use as large a generator as possible, with a limited pressure, say 2000 volts.

B. SPEER: You spoke of the number of "watts" in the primary and secondary circuits as the same. That is, of course, theoretical?

L. B. STILLWELL: Yes. You refer to loss in the conversion. That loss is dependent, of course, upon the construction of the converter. There are all kinds of converters. Some of them have a considerable loss, but a great many have very small losses. The latest converter I have seen tested showed a loss of a little less than 2 per cent., with secondary open circuited. It has not been tested at full load. The loss at full load would not be in excess of 4 per cent.

In reply to Mr. Payne's question: I did not speak of the problem of underground circuits, or the arrangement of underground circuits, for the reason that in our cities, except the very large ones, that is still a question for the future. There is no intrinsic reason why underground circuits should be safer than

overhead circuits, if the latter are properly constructed. For the great majority of American towns the overhead construction will, for many years I am afraid, still be necessary. As fast as these towns become densely populated cities, it will be possible to adopt the underground construction. The question is simply one of dollars and cents. The underground work will cost at least several times as much as the overhead construction. The underground construction is going on in New York now very successfully and it is the method usually employed in the large cities abroad. The problems in electrical construction underground are not very different from those in the overhead work. There is, of course, greater difficulty in insulating the circuits from the earth; better insulation and more of it must be used.

W. THAW: Have I not heard of the use of hollow copper cylinders one within another, in London? There is in this case very little insulation.

L. B. STILLWELL: I think you refer to the new station of the London Electrical Supply Company, which is at Deptford. The system employed by that company, or rather, I should say, the system which they propose to use, for I do not think it is yet in operation, is, as you say, one of concentric tubes, the outer tube having through its entire length and separating it from the inner tube a heavy layer of insulation. The tubes are made in sections and the connections are made by a special arrangement somewhat similar to the screw-thread used in water-pipes, with allowance for expansion.

W. THAW: When they take the current off at a station, where do they take it from?

L. B. STILLWELL: The proposition has been made to use at Deptford 10,000 volts pressure. That would be carried to sub-stations in the city. The centre of the district which the company proposes to light is about five miles from their station. At each of the sub-stations there are very large transformers to be used to reduce the potential from 10,000 to 2000 volts. The current would have to go through the outer tube to one terminal of the transformer and through the inner conductor to the other terminal.

A. E. HUNT: Speaking of the percentage of loss in the con-

verters, I would like to ask a question. Do you compare the percentage of loss actually in the dynamo or in the work that the dynamo will do like horse-power, with the work which the steam horse-power will give. For instance, you have your formula as so many watts divided by 746 giving such and such horse-power. How closely can you make your horse-power, or what factor do you use to indicate the horse-power to run that dynamo?

L. B. STILLWELL: As I understand, you mean, " What is the efficiency of the dynamo?" That is the same as with the converters; it is variable. Many arc-light dynamos are very inefficient. The reason is, in some instances, due to very high internal resistance. Some of these dynamos have very low efficiency, I think not exceeding 40 or 50 per cent.

W. THAW: Is it the fact that you can approach the best economy with large ampere and low voltage?

L. B. STILLWELL: No, I think there is no difference. I should say further that those arc-machines to which I have referred are the worst made, the least efficient. A good many dynamos are constructed giving an efficiency at least as high as 90 per cent., and I know of claims in excess of that. But I do not believe many of such claims are warranted by the facts. But there are many dynamos very efficient. I know of a number of tests showing from 85 to 90 per cent.

A. E. HUNT: Steadily?

L. B. STILLWELL: Yes, sir, under full load.

A. E. HUNT: Steadily, with the full load within 10 per cent.?

L. B. STILLWELL: Yes, running under full load and at their maximum temperature.

B. SPEER: What is the efficiency for the Westinghouse dynamos for arc-lights? Can you tell us?

L. B. STILLWELL: Yes, sir, I can. There was a test made about two weeks ago. Two dynamos were tested at the same time, one running 60 laps and the other 120. The actual candle-power of the lamps was not measured, but they were compared with ordinary arc-lights apparently giving at least as much light. The engine was indicated and the number of lamps in the circuit counted; the current flowing through the circuit and the difference of potentials at the terminals of single lamps were measured.

From the measurement of the difference of potential at the terminals of several lamps the total difference of potential in the circuit was estimated and multiplied by the product of the current, giving approximately the energy of the circuit. We had for comparison the indicator on the engine. The results of that test showed surprisingly high efficiency for the arc-light dynamo. The maximum figures were obtained at full load and were about 88 or 89 per cent., and at the half load, as I remember it, the efficiency was 70 per cent. or in that neighborhood.

W. L. SCAIFE: Did the experiments you mention indicate which current, alternate or direct, was the most dangerous?

L. B. STILLWELL: I did not refer to the answers received by the secretary of the Electric Light Association in so far as they dealt with shocks from alternate currents. But he had nineteen cases reported of shocks received from an alternate current at high potential. In seventeen of these cases the shock was taken from hand to hand. Such shocks, if the circuit is well taken care of, can only be received by linemen. They only can get such a contact. Not one of these cases was fatal. In another case the shock was received from the knuckle to the palm of the hand and in another case from hand to arm. Neither was fatal.

W. THAW then recited an instance of where a current was discovered coming down a wooden telegraph pole on Smithfield Street some weeks since, with apparently no conductor near. Mr. Stillwell replied that he could give no explanation of the occurrence if there was no wire near. The nearest wire was reported as thirty yards off, and it could not possibly have been received from it.

After passing a vote of thanks to Mr. Stillwell for his paper, the Society adjourned.

S. M. WICKERSHAM,
Secretary.

APRIL 15TH, 1890.

SOCIETY met at 8.15 P.M.

President W. L. Scaife in the chair.

Vice-President, Phineas Barnes; Director, W. G. Wilkins, and 30 members present.

The following applicants for membership were duly elected: W. A. Giles, William Morgan, James Ritchie, Frederick Schaeffer, Daniel Ashworth, Charles F. Scott; after which W. C. Quincy gave the following talk on

B. & O. R. R. ENGINEERING BEFORE AND AFTER THE WAR.

The notice does not state exactly what I propose to do this evening. I am hardly able to go back forty years and relate anything about railroad building. My purpose is to read extracts from reports of others prior to forty years ago, and to give you a few personal reminiscences of my connection with the Baltimore and Ohio Railroad during its construction and the trying periods of the civil war.

Most of my railroad papers in connection with early days in the service of the Baltimore and Ohio Railroad are packed away at my former home in Ohio. I am therefore unable to refer to them to-night. I have a few personal telegrams and some of the early reports of the Baltimore and Ohio Railroad, also copies of the annual reports during my thirty years in its service. I think extracts read from these reports and a talk upon personal reminiscences will interest you more than an original paper.

Let me first carry you back to the days of the pioneers in this enterprise, and read from the first annual report of Mr. P. E. Thomas, President, October 1, 1827. The report consists of but two pages, and shows that Mr. Thomas had a high appreciation of engineers. "The directors have also deemed it of primary importance, in the first instance, to secure the services of an engineer upon whose talents and skill they may safely rely. It is their desire, not less their duty, to obtain the best professional aid the country will afford, and they will spare no efforts to engage a superintendent of the highest character. The government of the United States, justly appreciating the importance of this enterprise, have extended to it a most liberal patronage. Several able and efficient members of the topographical corps have been detached to the service of the company. In conclusion, the board feel a

high satisfaction in stating, as a result of all the information and experience they have yet acquired, that their confidence in the practicability of the railroad remains unabated."

I will also read from the second report of Mr. Thomas, for 1828: "It is obvious also that with the prospect, almost arising to a certainty, of the greater amounts of trade being directed eastward, at least for a series of years, their engineers could not, with any regard to the economical application of motive power, admit on this part of the route *the least descent in its progress westward*, and since any greater elevation than that on which the road commences would but have increased the obstacle presented by the steep and rugged hillsides bounding the Patapsco, to say nothing of the disadvantages which would have resulted in passing the numerous broad and deep ravines, they were constrained to *sustain a level* at greater variance with the natural surface of the ground than will again be necessary."

The Board of Engineers state: "The natural surface in the immediate vicinity of the routes is generally firm and well adapted to the reception and support of a road. Quagmires are nowhere to be met with, muddy grounds seldom occur, and in no instance do they present any serious impediments in the way of easy construction. The hills are nowhere so abrupt and elevated as to render tunnelling necessary, although any route leading through them must maintain *a serpentine* course in order to preserve *a level.*"

The Board of Engineers go on to say: "The subject of horizontal curvatures or deviations from a right line, so far as may be inferred from a perusal of numerous treatises on railroads, seems never to have engaged the attention of engineers in due proportion to its importance. In vain have we searched in treatises of the description just mentioned for rules and computations of easy application in tracing the route of a railroad in situations where curves are unavoidable."

I will also read from the report of Mr. Benjamin H. Latrobe, Chief Engineer of Location, in 1836: "Upon the Baltimore and Ohio Railroad the curvatures were so great, being a radius of 400, and in one instance of 318 feet, that many doubted the practica-

bility of running locomotive engines upon it. However, in consequence of the perseverance of the President and directors of the company, an engine was placed upon the road in the year 1831 that could traverse all the curves with facility, and convey 15 tons at a speed of 15 miles an hour, *on a level.*"

From the same report I read: "Locomotive engines, such as have already been described in this and preceding reports, continue to be fabricated in the shops of the Baltimore and Ohio Railroad Company, by the contractors, and the performance of these engines has hitherto been highly satisfactory. Few trials of their extreme tractile power have been made since last year; such, however, as have been made, together with such as occasionally occur in the business of the road, may be briefly related. On the 12th of September last, being the occasion of the anniversary of the battle of North Point, several volunteer companies from this city and the counties adjacent, amounting in all to 900 or 1000 citizen soldiers, were conveyed to Washington and back by *four* locomotive engines, one of which conveyed about 300 troops with their arms and accoutrements. Now, although the full power of the engines were by no means brought into play on this memorable occasion, yet the result had a very impressive effect upon the many thousands who witnessed it, and who were thus furnished with ocular proof of the new and immense facilities created by railroads and locomotive engines upon them, in the transit of persons and property, and in fact of whole armies and their accompaniments. The trains here mentioned advanced to Washington in the morning and returned the evening of the same day, and as the return was effected with speed and safety, *notwithstanding it was dark*, a confirmation was had of the practicability and facility of locomotive travel *by night* as well as by day."

During the month of March, 1849, through the influence of Mr. Benjamin Deford, a personal friend, and a director of the Baltimore and Ohio Railroad, I obtained employment as chainman in the engineer corps. In those days boys of my age were paid from $1.50 to $2.00 per week. When Mr Latrobe told me my pay would be $1 per day I felt that I was assured, not only occupation, but a fortune. I reported for duty to Mr. Charles P.

Manning, at Cumberland, Md., and was engaged upon location until the summer of 1850. I was appointed assistant, and subsequently, resident engineer of construction. We boarded for several months with Mr. Henry Church. He was an English soldier of the Revolutionary War, was taken prisoner, and settled at Cappofork, Va. He was then 101 years old. For his kind attention to us a flag station was established on his farm and called "Old Hundred."

In this connection I will relate an incident which occurred at the time we were building the road. I asked the old gentleman the price of timber. He said, so much. "Mr. Church," I replied, "that is entirely too much." He answered, "It will be worth more than that to me twenty years from now."

There were many tunnels, and my connection with them was as assistant engineer in the building of four, engineer of ten, and the arching of six; twenty in all. The building and the arching of some of the tunnels was difficult and hazardous, Kingwood and Board Tree tunnels particularly so. I was not connected with the former tunnel, but will read an interesting report from Mr. Bollman, then Master of Road in 1856.

"The great difficulty attending the arching of this tunnel has been owing principally to the nature of the material or rock through which it passed. By exposure to the atmosphere it rapidly decomposed, which caused it frequently to fall in such large masses as to block up the tunnel for a considerable distance, to the depth of 8 or ten feet, besides upon the timbering, which was first introduced to prevent accidents to the trains by falls from the roof, such large quantities of loose rock had accumulated, that when the timbers were removed to make space for the arch, it frequently by its great weight, caused the timbers to give way and crushed all beneath it. It was, therefore, necessary for the protection of the workmen to perform this part of the work with extreme caution, and considerable skill, energy and expense were requisite to accomplish it. The unfinished part fortunately has a roof of better material, and with the exception of having to take down a part of it to allow sufficient room for turning the arch, all difficulties and dangers are now removed. I indicated that a part

of the arching was composed of cast-iron, to which some objection may be raised on account of its tendency to deterioration from rust, etc. And to remove all apprehensions on that point, I would say that that important consideration was not lost sight of, but that a plan was adopted and fully carried out, in the execution of the work which will, in case the iron arch should be destroyed, fully sustain the roof for all time to come. This plan simply consisted of forming a rough arch of sandstone, which was convenient to the tunnel and well adapted to the purpose, immediately upon the top of the iron arch of a most substantial character. This auxiliary arch of stone did not, as some might suppose, add materially to the cost, for it must be borne in mind that the space between the part of the main arch and roof of the tunnel must in all cases be well packed with hard and durable stone, and, therefore, the stone arch only occupies the space of so much packing, and costs but a fraction more in the aggregate. A brick arch would have cost less than an iron one, and would have been preferred under ordinary circumstances, but the difficulties we had to contend with drove us in a measure to the adoption of the latter, for without it I believe certain parts of the tunnel could not have been arched, unless indeed we had disregarded the lives of the workmen and security of the trains as they passed through.

"Each section of the iron arch is composed of two segments, each of which is nearly equal to a quadrant, 3 feet wide and ¾ of an inch thick, with two ribs each ¾ inch thick and 6 inches deep, attached to the soffit, and when in position the heels rest on the top of the side walls, and are secured at the crown, where they abut by iron bolts. The iron arch was well protected by paint and pitch to prevent as far as possible the action of rust. The facility with which these sections were placed in their position in the tunnel, and the security they gave to the workmen, was truly astonishing. By means of an ingeniously contrived hoisting car, the segments were carried and set up in the tunnel in the short time of from five to ten minutes to each section, equal to three lineal feet of arch, and immediately thereafter props, to prevent heavy falls from the roof, were rested upon them, which made all comparatively safe, until the packing was completed.

"After a careful inspection of this interesting piece of work, I think the Board will agree with me in saying that it stands unsurpassed for durability, and also, when all the difficulties attending its progress are carefully and impartially weighed, to conclude that, although the expenditure appears large, it could not have been done for less."

I will also read from the report of 1852:

"The same expedient of a line over the hill at Board Tree will be resorted to as at the Kingwood tunnel, viz., the passage over the natural surface of the ridge by gradients of steep inclination. The summit over this tunnel is 300 feet high, being 80 feet greater than that of the Kingwood tunnel, yet the inclines are so located as to give planes of much less acclivity, there being no ascent greater than 6 feet in the 100, instead of upwards of 10 *feet in the hundred*, as at the Kingwood ridge. A locomotive will, for this reason, perform twice as much work as upon the latter grade, and there will be no risk of the train sliding backwards with locked wheels, as occasionally happened on that grade when the rails were slippery."

Is it a matter of surprise that when witnessing for the first time the locomotives ascending these grades Mr. Latrobe, the chief engineer, raised his hands and exclaimed, "Wonderful! wonderful! wonderful?"

The annual reports of the Maintenance of Way department from 1858 to 1868 were written by me, and I will refer to and use them. My first work connected with the arching of tunnels was at Boardtree tunnel, and our experience was similar to that at Kingwood, but the mass of loose material on top the timbers was much greater, being from 10 to 26 feet. We worked in from the sides between the timbers with about eight gangs of miners, removing this mass, and when the timbers were taken down the section of the tunnel was 18 feet wide and 30 to 50 feet in height. Heavy falls occurred, at great risk to the lives of the men. The roof and sides were in many places beyond the reach of poles, and continual falls of rock delayed the progress of the work. Each mason and bricklayer had a watchman to warn them of falls. If

my memory serves me, over 30 men were killed and 300 injured in the arching of this and the Kingwood tunnel.

During the years 1866–7, in addition to other duties, I had charge of the building of second track and three tunnels at the Point of Rocks. I quote from the President for 1866:

"The protracted litigation and delay in building the road in the early history of the company, caused by the conflicting claims of the Chesapeake and Ohio Canal Company for the right of way through the narrow and difficult passes of the upper and lower Point of Rocks, will be remembered. The same lofty and precipitous mountains of rocks again presented, on the north side, their barriers to the construction of the second track, whilst the Chesapeake and Ohio Canal interposed between the single track and the Potomac river. As the line could be materially improved, heavy curves being thus avoided, and the continuous double track secured, it was determined to construct a tunnel 800 feet in length at the lower, and two tunnels about 700 feet in length at the upper Point of Rocks.

"The rock proved peculiarly flinty and hard, but by working large forces night and day from four different points one-half of the first tunnel was completed and the work on the approaches and much difficult side-cutting near the canal for the upper tunnels were accomplished, whilst navigation was suspended in the winter months. Similar though less serious difficulties were encountered on the upper Potomac.

"In consequence of the limited margin for the road in many portions of that valley it became necessary, in order to secure the width of the road-bed required for the second track, either to fill out and make embankments in the river, or to cut into the rocky mountain sides. The latter plan, though more difficult and costly, was adopted, and thus a first-class, secure and permanent line was obtained.

"Notwithstanding the heavy and difficult character of the work, 70 miles of superior second track were constructed during the year."

My report is mainly to the same effect. Forces worked day and night. At times the progress was only 4 feet per week; for many

of the heading holes it was requisite to sharpen over *one hundred and ten* drills to bore *thirty* inches. I remember the foreman who had charge of the work, James Collins, a very faithful fellow. It was his delight whenever I came along to call my attention to some of his men. There was a very large man among them, named Enos McDonald; he called him "Big Enos;" and Patsy Joyce and others. I cautioned him to be very careful and not obstruct the track; his reply was: "No danger; if a rock gets on the track as big as a shanty, big Enos and Patsy Joyce could get it out of the way without delay to trains."

A few days after this conversation Collins met me on the train. He appeared all broken up, and I asked him the matter. He replied: "A liquor shanty has been built near the end of the tunnel; many of the men are drunk, and I cannot get any work out of them." I expressed a wish that some night the men would get drunk, tear the shanty down and destroy the liquor. He said: "Do you wish that?" I replied, "Yes." "When will you be back?" "The day after to-morrow."

On my return Collins met me on the train and asked "if I had heard of the misfortune." I replied "No." I supposed some of his men had been killed. He said: "Some of my men got drunk and tore that shanty down and destroyed the liquor." Adding, "I am investigating it, and as soon as I find who they were I will tell you." I did not ask him to press his investigations. I felt that if big Enos, Patsy Joyce and others were capable of removing a rock as big as a shanty in a few minutes, they could certainly remove the shanty itself during a night.

I will mention that the Chesapeake and Ohio canal at the time of the construction of the road had the prior right of way; its boundary was distinctly marked by iron pins in the side of the bluffs, 40, 50, 60, 90 feet above the railroad. The canal company brought suit against the railroad company, and it was argued by the best lawyers of that day. The canal company suggested to the railroad company "as the railroad would not amount to anything, they had better take the money they had and help build the canal." The president of the railroad company wrote a letter suggesting that "both the canal and the railroad should be

built to the point of conflict, and after it was demonstrated which served the public best, the other should be abandoned." The matter was finally adjusted by the railroad company building the canal, and also the railroad along this narrow passage. The legislature of the State of Maryland, during its last session, 1889, authorized the sale of the canal to a railroad company.

During the first year of the war I prepared a chronological table of the leading events of the war, as connected with the destruction of the road by fire and by flood, and handed it to President Garrett. He instructed me to include it in the annual reports, and refers to it in his report as follows:

"The report of the maintenance of way department furnishes many interesting facts regarding the repeated destruction and restoration of the road and works of the company. The chronological table in the report of that department embraces full historical information of the varied losses and operations of the company in connection with reconstruction, to which the Board invites special attention."

I will read some of the most important events, and relate personal reminiscences connected with them. "On the night of the 18th of April, 1861, the detachment of the United States regulars guarding the arsenal at Harper's Ferry, after setting fire to the buildings, evacuated that point. At 10 P.M., Virginia State troops marched in and took possession, placing a guard of infantry and artillery upon the bridge. The trains continued to run with many interruptions until May 25, 1861, at which time the large rock at Point of Rocks, supported by masonry, was undermined and thrown upon the track. On the following day, Buffalo Creek bridges, Nos 3 and 4, were burned. This destruction was the precursor of losses by fire and flood which followed in rapid succession. They will be noticed in chronological order." After the occupation of Harper's Ferry, in April, 1861, through trains were run until the 25th of May. The Union forces, under General Butler, were stationed at the Relay House; at Harper's Ferry were found the forces of Stonewall Jackson; at Cumberland, Union forces; and at Grafton, Virginia state troops. For a period of nearly two months trains were run through the lines of

both armies. I had frequent interviews, in regard to matters connected with the operations of the road, with "Stonewall" Jackson, Colonel Ashby, and other officers, during their first occupancy of the line, and afterwards with many of the generals of the Federal army. I made the acquaintance of nearly all the generals who were along the line of the Baltimore and Ohio Railroad except, perhaps, "General Result."

I will never forget the exciting and stirring scenes of the night of the 18th of April, 1861, and many subsequent events of the war. I left Baltimore on the morning train, and reached Harper's Ferry at 12 o'clock, noon. I noticed two gentlemen get off the train at Harper's Ferry; and a large crowd of persons assembled on the platform said to them, "Well, how is it?" They replied, "The State of Virginia has passed the ordinance of secession, and troops are now marching to capture Harper's Ferry." One of these gentlemen was Colonel Barbour, who had charge of the arsenal. I thought it important to remain and watch matters. There was much excitement during the afternoon; speech-making, drinking, and threats to burn the bridge. About 2 o'clock, desiring to inform President Garrett, I went to the telegraph office. I was greatly surprised to find the first soldier of the war guarding it. I said, "Well, soldier, where do you come from?" The soldier, with much more dignity than I had shown, replied, "What do you want, sir?" I replied, "I want to go into the telegraph office." He answered, "The telegraph office belongs to the State of Virginia." I said, "Does it? I supposed it belonged to the Baltimore and Ohio Railroad Company." I sent to the next telegraph station a message to Baltimore, advising the condition of affairs, and to send me a special engine and telegraph car, and on arrival to attach the wires about a mile below Harper's Ferry. After a few hours, the engine and car came over the bridge. The conductor informed me they had left the telegraph car on the other side of the river. The excitement abated towards night, but as a precautionary measure I had a large number of barrels filled with water placed upon the bridge. I also placed additional watchmen on the bridge. Conflicting reports that 500 or 600 soldiers were within a mile of Harper's Ferry were contradicted

by others that there were none between there and Winchester. I said to the engineer, "I will go into the car and lie down; If anything happens, waken me, and we will go down to the telegraph car and telegraph to Baltimore." I had been in the car but a moment when I heard shots on the bridge. The Virginia troops were firing at Jones's men as they were retreating. I hurried to the front of the car and called to the watchmen to look out for the bridge; as I did so, the engineer started his engine; I climbed over the tender and on to the engine; by the time I succeeded in doing so we were about half a mile below Harper's Ferry. I called to the engineer, "Stop, where are you going?" He replied, "You told me if anything happened we would go to Sandy Hook and telegraph." "But," said I, "We do not know that anything has happened." He said, "Did you not hear the shots on the bridge?" "Yes, but we do not know that anything has happened. Go back where you started from, and I will ascertain what to telegraph about." He backed the engine, and by the time we reached the bridge the whole place was illuminated, and explosions were frequent. Lieutenant Jones, in his retreat, had set fire to the buildings, and trains of powder laid in them caused the explosions. Every one was endeavoring to save the guns from the arsenal. Almost every man had one or more muskets. I remember seeing one of my foremen, Mike Dunn; he also had a musket. He came to me, presented, and said, "Mr. Quincy, I am here." It was a pity to dampen the ardor of this valiant man, but I told him to put the gun away and to get a bucket of water, he could do more good with it. Just then, one of the watchmen came and reported that men had gone on the bridge to burn it. I started after them, and found them with kindling wood preparing to fire the bridge. I asked them what they were going to do. They answered, "Burn the bridge." I asked, why? They answered, "There is a regiment of soldiers coming up from Baltimore, and we are not ready to meet them." I told them I was familiar with the movement of troops on the line, and I knew there was not a soldier between Harper's Ferry and Baltimore. They asked me who I was, and how I came to know so much. I told them who I was; they then said (and I remember it was the first fright I

had), "Have you not been here to-night with an engine and car, and have you not helped Jones and his troops to escape into Maryland? If it had not been for you we would have captured them." I realized my unfortunate position, and at once answered that there had not been a soldier on the car. They then asked me what I was doing there with the engine and car. I did not care to give this information, but I again assured them that there had not been a soldier on the car; and added, "If it will satisfy you I will remain until to-morrow, and if, upon investigation, you find there has been a soldier on the car, or *en route* from Baltimore, punish me." One of them said, "Cap, that's fair enough." And under promise not to leave until after I reported the next day they spared the bridge as well as myself.

I recrossed the bridge to Harper's Ferry. The telegraph operator came to tell me the guard had left his office. I instructed him to go back and put out the lights and I would follow him. I telegraphed to the next stations east and west the condition of affairs, directed all trains stopped until they heard from me, and failing to do so, not to permit any train to come to Harper's Ferry without first ascertaining that it was safe to do so. I also telegraphed my wife, "Do not be alarmed about me, I am O. K." Going out of the telegraph office I found a company of artillery placing a twelve-pound brass cannon upon one end of the bridge, and also a company of infantry. The officer in command said, "Now men, take your position here and if a train approaches give a signal to halt. If they do not halt instantly, fire into them." I said, "I have just heard the orders you have given these men, sir, and if carried out you may kill some one, and regret having done so. It will be impossible if a train approaches to stop it instantly. If you want it stopped at this point, you must send a guard some distance up the road to signal it, and after doing so, if they pass the bridge fire into them. I will go up with the guard and show them how to signal. But you will not be bothered with trains for I have stopped them." He asked, "Who are you, and what right have you to stop trains?" I informed him who I was, and arranged to go up with the guard and show them how to signal trains. Soon after the operator came to

me and said, " Mr. Quincy, Martinsburg telegraphs that fast stock train left before receiving your telegram." This filled me with apprehension because they were already suspicious that I had carried Jones' troops over the bridge, and as I had said all trains had been stopped, if a train approached they would fire into it. I found the officer and explained, telling him it was not a troop train. The train approached slowly. The trainmen supposed the bridge was on fire. After examination the officer permitted it to proceed.

I remained at Harper's Ferry until the next day and then reported to the captain. He said they had investigated the matter and had no charges against me. In this connection I will read, from *Battles and Leaders of the Civil War*, by Lieutenant Jones; " As the evening advanced nearer and nearer came the troops from Halltown and finally, shortly after 9 P.M. when they had advanced to within a mile, the torch was applied; but very few arms were saved, for the constantly recurring explosions kept the crowd back. I have heard that within a few minutes after my command had crossed the Potomac to the Maryland side of the river, a train was heard starting off for Baltimore and that it was assumed by the Virginia troops and their officers that my command had been taken off by that train and that consequently pursuit was useless."

Whilst we were running trains across the bridge, petards were placed between the braces to destroy it. They were made of cast-iron pipe about 2 inches diameter, about 2 feet long, the ends stopped with wrought-iron plugs; into these a piece of safety fuse was inserted. I had the watchman secure one which I afterwards took to Baltimore and had considerable amusement at the expense of the railroad officials who were afraid to have it in the building.

In January, 1862, General Lander was appointed to take command of the forces at Hancock and asked Mr. Garrett if an officer of the road would accompany him. Mr. Garrett told him he thought I would. The next day we went by rail to Frederick and thence by stage to Hagerstown, intending to remain there over night. The General was a brave soldier, an excellent man, but at times a little profane. About 11 o'clock he sent for me and said "Quincy they are fighting like h–l at Hancock." " Well," said I, " What have I to

do with it?" He asked, "will you go there with me to-night?" I replied, "I started from Baltimore to go with you." We left about midnight. I said, "you will have work to do at Hancock to-morrow; sleep and I will keep guard." He placed a brace of pistols on the front seat of the carriage; I called him during the night; he was alarmed and seized the pistols. I said, "there is no danger; I believe I am freezing." He took a flask from his satchel and told me to drink freely. I believe that little "speak-easy" saved my life. We reached Hancock about 5 o'clock the next morning and found great demoralization. We walked along the streets in the dark until we found a soldier with a gun in front of military headquarters. On entering, one of the officers, supposing I was a member of the General's staff, said to me, "I do not like the position of my guns near the church;" I replied, "I will look at them in the morning." After we reached headquarters, we obtained a bed by the General ordering out two officers who were occupying it. Referring to this event General Imboden in *Battles and Leaders of Civil War*, writes as follows: "Another force moved from Winchester and on the 4th of January the town of Bath was occupied after being abandoned by a body of Union troops, composed of cavalry, infantry and artillery. Jackson followed the retreating troops to the river and promptly bombarded Hancock, Md., without, however, securing a surrender. The weather was inclement and intensely cold. Many in Jackson's command were opposed to the expedition, but in that terrible winter, march and exposure, Jackson endured all that any private was exposed to."

About the 1st of March, 1862, Gen. Lander, then at Pawpaw, telegraphed me to come there. I went and he told me his plans to make an advance on Winchester and desired the bridge at Sleepy creek trestled. He asked how long it would take. I replied, "it depends altogether on military protection, interruptions, etc." "Well," he said, "if you will let me over in two days, I will give you the best watch and chain that can be bought. But if you don't let me over in two days, I will hang you." I replied "I do not want a watch and to hang me would be an ungrateful return for my trip to Hancock with you." We built the bridge, but he never crossed it, as he died the following day.

Washouts by flood or burnouts were frequent during the war. The trestling in the Potomac was difficult, the river bed being very irregular, and much difference in the length of the trestle legs in same bent. After a washout, two or three days would elapse before a boat would live in the current, and then it was necessary to spike railroad bars to the trestle legs to sink them. The chronological records show that in March, 1862, orders were given to repair and re-open the road and on the 10th it rained hard and the river continued too full and the current too swift to accomplish much at the main bridge at Harper's Ferry. On the 12th work was resumed and pressed with all possible energy until the night of the 18th, when the first locomotive for nine months crossed over into Harper's Ferry. A few days thereafter the road was opened for traffic. Every bridge from Harper's Ferry to Cumberland had been destroyed, all the water stations, and 42 miles of main track, the iron rails carried away, so that we had a difficult task to restore the road for traffic.

On its completion, I received the following telegram from President Garrett; "Camden Station, March 31, 1862. W. C. Quincy, I congratulate you. The achievements of the Road Department are such as to attract great attention and command the highest satisfaction of the Company. Your personal energy, and persistent and successful efforts are fully appreciated."

Mr. Prescott Smith, the master of transportation, who was a little more enthusiastic, telegraphed: "Consider yourself saluted by 3000 cheers and 5000 guns for your successful efforts in restoring the road. I congratulate you. You have achieved much and shall receive the credit due you."

On the 29th July, 1863, we were laying track beyond the Opequan Bridge, 18 miles west of Harper's Ferry. (I was admirably served by my telegraph operators. They, during the trying periods of the war, kept me fully informed). About six o'clock in the evening, the operator came and told me "to look out for squalls," that the commanding General had sent an order to the cavalry guarding us to get over into Maryland as quick as possible, as there were 800 men within five miles to capture the railroad men." I walked to Martinsburg, two and a half miles, found

the carpenters who were building the bridge at that place at supper; told them it was likely Mosby would be there *the next day* and that we would fall back to Harper's Ferry. We walked back to Opequan and thence by train to Harper's Ferry, returning the next day with military guard. We found it was a false alarm, and finished track laying. A few days after I returned to Baltimore and went into Mr. Garrett's office. He welcomed me kindly, was glad we had finished the work so soon, but added it would have been completed a day earlier if it had not been for your unfortunate retreat from Opequan. Said I, " Mr. Garrett, we were left without military guard and I thought it proper to go back to the protection of the guns at Harper's Ferry. "Why," said he, "I was not at all alarmed." I replied, "I would not have been either in this office one hundred miles away, but it is altogether different being at the front and sleeping in an old car." He replied, "that does make a difference."

Referring again to the report, I find that on the 10th of April, 1864, the rivers and small streams were much swollen, but by constant vigilance at all the trestling, trains were worked through with but slight interruption until April 10th, when the Potomac river at Harper's Ferry became swollen to a great height with much drift running. The trestled spans as a precautionary measure were weighted with loaded cars upon them. At 11.40 P.M., the wide span, including the Winchester span thereupon was swept out, carrying with it the cars with which it was weighted. The river continued to rise; on the following day the current was so swift that it became evident that it would be impossible to cross even in boats for several days. There were at the time large bodies of troops on the line *en route* for the defense of Washington and extraordinary measures had to be determined upon in order to ensure their prompt transportation. Standing on the Maryland side, and looking over into Harper's Ferry, I could see troop trains extending far up the track. The river was running full of drift and everything was most discouraging. I telegraphed Mr. Garrett the condition of affairs, telling him the bridge had gone out, and as the troops were for the defense of Washington, he had better at once order them sent by the way of Pittsburg and the

Northern Central railroad. He replied, "I have your telegram. *I rely upon you to cross the troops.*" I showed it to the foremen and asked what we could do? They replied, "you know it is impossible to work in the river for three days." I asked Capt. Pengaskill, who had charge of the pontoon corps if he could furnish boats or any temporary expedient to cross the troops, I would furnish the men to do the work. He replied, "I have but one boat and it is impossible to do anything." I again telegraphed Mr. Garrett I was fearful he did not realize the situation, stating the condition of the river, the drift, etc., and urged him to order the troops via Pittsburg. He replied, "I repeat my first telegram. *I rely upon you to cross the troops;* they will not be ordered back." I walked out to the pier, and as I gazed wistfully at the river the thought occurred to me that the easiest solution of the matter would be to jump in and drown myself, but my life was saved by a little cast-iron washer. I noticed it on the pier and picking it up said to the foreman, "Have you a man who can throw this with a string attached over into Harper's Ferry?" He answered yes. We had every appliance that could be thought of from a spool of thread to a 6-inch cable, with all necessary blocks, tackle, etc. I ordered wire cables from Baltimore by special train which reached its destination on the morning of the 12th. Previous to its arrival a small line with weight attached had been thrown across the opening; by means of this larger lines each increasing in size were passed and repassed until a 5-inch cable was secured, upon which the wire ropes were taken over, and at 5 P.M. of the *same day* the passengers from delayed trains and regiments of troops were passed safely over an improvised suspension bridge. I telegraphed Mr. Garrett what I had done, and he answered, "*I was satisfied you would cross the troops.* The energy and zeal of the officers and men of your department are highly appreciated." I remember when I informed the foreman of bridges we would build a suspension bridge, he asked for the plan. I told him I had none but will guarantee if we get a line across to build one sufficient to carry the troops.

During the war many locomotives, cars, rails, track-fixtures and machinery were hauled by animal power over turnpike-roads from the line of the road to the railroads in Virginia. These locomo-

tives and cars were used to transport Johnson's troops to reinforce Beauregard at Bull's Run, and it will be remembered, their timely arrival caused the defeat of the Union armies.

I read sometime since, a report on this subject, which did not agree with my chronological table, and I wrote to an acquaintance in regard to it. He replied: "I have yours of the 19th. When I went to Winchester, in June, 1861, I found on the Winchester and Potomac railroad one hundred and sixty Baltimore and Ohio box- and gondola-cars, which I hauled from Winchester to Strasburg. I hauled, from Martinsburg to Strasburg, ten locomotives and all of the machinery in the shops at Martinsburg. Then I hauled from the road-crossing, about a mile east of Duffield, over to Halltown five locomotives, which I found standing on the siding at Duffield. I took these over the Winchester and Potomac road to Winchester, and hauled them to Strasburg. The old engine '32' was left at Harper's Ferry. I rebuilt the bridges between Harper's Ferry and Halltown, and took it to Winchester where I left it. At the time of the evacuation of Manasses, I had two Baltimore and Ohio engines and one Manasses Gap engine, and six or eight box-cars at Strasburg. I was at that time military-railroad superintendent at Manasses under General Johnson, and I ordered the three locomotives and the six or eight box-cars sent to Mt. Jackson by rail, and then hauled them down the valley from Mt. Jackson to Staunton, fifty miles, put them on the Chesapeake and Ohio railroad, and took them to Richmond. All of the hauling was done by horses over the wagon-roads, using from twenty-two to forty horses to an engine, according to the size. These are the facts of the case, all of which are verified by my records, which I still have. All the rails taken up, were hauled to Winchester and Strasburg; some used to build railroad from Manasses to Centerville, others rolled into armor-plates at Richmond and put on the Merrimac."

March 30, 1865, the mail-train from Baltimore to Cumberland was captured. As guerrilla forces were reported near the road in many places, I took charge of the movement of the train. We reached Greenspring Run about dark, and, as three thousand Union troops were there stationed and a like number at the next station, I felt that we had passed the danger-point, but midway at

Dan's Run a rail had been taken up and the train left the track. On looking out, I saw guerrillas with pistols in their hands approaching the train. I had an order in my pocket, from Secretary Stanton, giving me temporary charge of the Winchester railroad for the government, and my first thought was this order. I tore it up and threw the pieces out of the window. These guerrillas boarded the train, and their manner of pressing a revolver against my face had a most impressive effect. It was my custom to carry about eighty dollars in gold for use in case of capture. I had put this, excepting five or six dollars, in my boot, and handed over my pocket-book. Another presented his revolver and demanded my watch. I replied, "They have already taken all I have; ask them to divide with you." He took my hat, and left me with my watch in my pocket. They ordered all the men "to leave the train and come *this way*." It occurred to me I would *go the other way*, and I got off the far side of the train and, by keeping in the ditch close to the cut, was soon out of sight. I was startled by discovering a man standing near the track, and, supposing he was on guard and would take me prisoner, I approached in the most humble manner, and said: "My dear sir, can you tell me where I can find shelter? I was on the train, they have taken my money and my hat, and I do not know what to do, or where to go." He replied, "*They took all I had, too.*" He ran away before I did. I said, "Come with me and I will take care of you," telling him I had a perfect knowledge of the country, etc. We walked to Greenspring Run, distant three miles, and the next morning at daylight I returned and cleared the wreck.

In conclusion, I will state that, in February, 1861, I was directed by President Garrett to take President Lincoln in my car to Washington, but a change in the programme left me to take Mrs. Lincoln, Colonel Ellsworth and others safely to Washington instead. April 15th, 1865, I accompanied General Grant to Washington, and, on the 21st of same month, upon the invitation of the Secretary of War, I accompanied the honored remains of the late President Abraham Lincoln *en route* to Springfield, Illinois.

Society adjourned at 10.05 P.M.

S. M. WICKERSHAM,
Secretary.

MAY 25TH, 1890.

SOCIETY met at 8.15 o'clock P.M. at the rooms.

Present, President W. L. Scaife; Vice-President, P. Barnes; Directors, M. J. Becker, W. G. Wilkins; Secretary *pro tem.*, F. C. Phillips, and 33 members.

The Board presented the applications of the following gentlemen for membership, who were duly elected: H. J. Lewis, J. H. Barrett, R. R. Singer, Hakon Hammer.

The Committee on Affiliation made the following report, which was adopted:

REPORT OF COMMITTEE ON AFFILIATION.

GENTLEMEN: Your Committee appointed to confer with the American Society of Civil Engineers with a view to establishing a closer relationship between the various engineering associations of the United States, respectfully submit the following report:

A considerable number of engineering societies now exist in the different States, each possessing local peculiarities and satisfying local wants. Being organized to accomplish different aims under different circumstances, they possess a vitality and an individuality—and, therefore, a value—which could not be increased by any other single plan of organization known to your Committee. For any one society to attempt to form a "protectorate" over these associations, or to turn them into "branches" governed by the same rules, would be, in our opinion, either unsuccessful or disastrous, as tending to check their natural birth and development.

We fully recognize the unfortunate fact that the isolation of these local societies is a direct loss to the engineering profession and to the country, whereas their successful co-operation would ultimately give an incalculable impetus to the engineering progress of the United States and of the world.

Engineering, in its various branches, is perhaps the most powerful factor in the material progress of this country, and yet engineers, as a body, have very little influence in national or state legislation, however worthy the object may be, principally because they lack the power due to concentrated aims and efforts.

The American Society deserves credit for attempting to increase its own usefulness and that of other engineering bodies throughout the United States; and in view of the foregoing remarks we would suggest the following general plan in reply to the inquiries of their Committee:

1st. That the American Society and other engineering associations of the country form a federation, which shall leave to each society its autonomy and individuality.

2d. This federation to be governed by a council, whose members shall be delegates from the constituent societies, chosen on a basis of numerical membership; but each society to have at least one representative.

3d. This federative council to possess powers delegated to it from time to time by the societies, such, for example, as the selection of local papers for its transactions; the determination of conditions of transfer of a member from one society to another; the interchange of published transactions; and the investigation and discussion of subjects of national importance.

The president and secretary of the American Society might occupy similar positions in the council, whose place of meeting, at stated periods, would naturally be New York.

By means of such a federation the American Society would preserve its present high standard of membership while gaining many new members and additional influence as the acknowledged head of a powerful, active and extremely useful federation of engineering societies of the United States.

W. L. SCAIFE,
THOMAS P. ROBERTS,
JOHN W. LANGLEY,
Committee.

PITTSBURG, MAY 20TH, 1890.

After the report of the Committee on the Proposed Federation of American Societies was read,

MR. LANGLEY said: I may say just one word by way of explanation. The report of this Committee is only preliminary. In fact, it is necessarily not final, because the invitation of the American Society, under which this Committee was appointed,

looks to a conference in New York of representatives of various societies, and it is a part of the duty of this Committee, as originally appointed, to attend this conference.

The Library Committee reported that a series of the publications of the United States Coast and Geodetic Survey has been received from the Superintendent of the Coast Survey, Prof. T. C. Mendenhall.

On motion, the thanks of the Society were given to Prof. Mendendall for his attention to our interests.

M. J. BECKER, before beginning the reading of his paper on the construction or replacing of one of the piers of the Steubenville bridge, said: I am really apprehensive that before I get through with the reading of this paper I shall be called to order by the chair for violating the first section of the By-Laws of this Society, which, if I recollect right, provides that the regular meetings of the Society shall be devoted to the reading and discussion of papers on scientific subjects.

Now, I may as well say right now that the text of this paper is not upon a scientific subject at all. It is simply the story of one of those occurrences which happen frequently in the practical execution of engineering works, and which lead in their correction to difficulties which very often are somewhat troublesome to overcome.

And yet these occurrences are in a measure useful because they teach us how not to do things, and it is simply with that view that I am induced to read this paper, and I wish you to simply consider it in the same light.

Mr. Becker then read the following paper:

A TEMPORARY BRIDGE SUPPORT.

The foundations for the piers of the channel span, and for the two piers east of the channel span, of the Ohio river bridge at Steubenville, Ohio, were laid in 1862 and 1863, and the masonry of these piers was completed in 1864.

The west abutment, a portion of the east abutment, and parts of the remaining piers had been built as early as 1855, but financial embarrassment compelled a suspension of the work until the re-

sumption in 1862, when such portions of the old masonry as were found in good condition were utilized and finished.

The bridge consists of eight spans, and its total length is 1910 feet. The three western spans are 210 feet each, the four eastern spans are 231 feet each, and between these two groups is the channel span of 320 feet length. The channel span is a so-called "through" span, the track resting on the lower chords of the trusses; all other spans are so-called "deck" spans, the track resting on the upper chords of the trusses, 90 feet above low water in the Ohio river.

The original superstructure of this bridge was of the well-known "Linville" type, named after J. H. Linville, C.E., of Philadelphia, who designed and built it. At the time of its completion, in 1865, it was the only iron railway bridge across any of the navigable tributaries of the Mississippi river, and it was the longest span iron-truss bridge ever attempted up to that time.

The foundations for the piers of this bridge consisted of ordinary timber platforms, composed of three or four courses, bolted together and sunk into pits excavated in the river-bed by dredging-machines. The sequel will show that this method is not to be recommended as an example for general observance. After the foundation pits had been excavated to their proper depths, the timber platforms were floated into position, secured by guide piles at the corners, and gradually lowered by the increasing weight of the masonry as it was laid on the platform, until they finally settled upon the bottom of the pits. It was very difficult to maintain a smooth and level surface at the bottom of these pits during the lowering of the platforms, the under-current washing out the shifting material in some places and depositing it in others, causing great inequality at the bottom, and preventing the platforms from finding uniform bearings.

This was especially the case with Pier No. 5, which is the pier between the two spans next east of the channel span.

When the foundation pit for this pier had been dredged out to its required depth, the platform, consisting of three courses of 12-inch pine timber and a top layer of 2½-inch plank, was floated into position, and gradually sunk by the increasing weight of the

masonry built upon it. It was not expected that the platform would at once come to a full bearing, and its slightly irregular settling during the laying of the first two or three courses of masonry created no surprise; but after the fifth course had been laid it was supposed that a firm bearing had been reached, and that no further settlement would take place. Levels were taken on top of this course, showing a depression of 7 inches at the up stream end of the pier as compared with the down stream end; and an average transverse depression along the east side of the pier of 1½ inches.

The top of this course was then trimmed to a uniformly horizontal surface, and the masonry continued to the top finish, without signs of unequal settling. But just before the erection of the superstructure, it was discovered that the pier had suddenly settled westwardly, so as to show on its top a departure of about 22 inches from its normal longitudinal axis. This movement eliminated the batir on the west side of the pier entirely, and increased it on the east side from the original ratio of ½ inch per foot to about 1 inch per foot. The question then arose whether it would be safe to place the iron superstructure upon this leaning pier. A careful examination found the masonry in perfect condition without a sign of fracture in the stone or of a rupture in the joints. It was evident that the west edge of the platform had at first lodged upon the slope of the pit and rested there until the pier was completed, when it started and settled to the bottom of the pit, carrying with it in its movement the body of the pier intact. There was still room enough on top of the pier for the support of the trusses, although the bed plates of the end posts of the eastern span came rather uncomfortably close to the edge of the coping.

After a short consultation it was decided to erect the superstructure upon the pier as it stood, protect its base with a large deposit of riprap; make regular periodical observations so as to detect any possible additional movement, and trust to luck for the rest.

The pier has stood firm and carried its load from that time until last fall, for a period of twenty-five years.

During the summer of 1888, the four eastern spans were taken down and replaced with a double track superstructure. It had

been decided to take down and rebuild the leaning pier at the same time, and it was the intention to accomplish this by placing the two spans adjacent to this pier upon false works simultaneously, and begin the removal of the pier just as soon as the track had been placed upon the false-works trestles, and the dismantling of the trusses had commenced. By working then vigorously day and night on the removal and rebuilding of the pier, we hoped to complete it in time for the reception of the new superstructure. Under favorable circumstances this could have been done, but, unfortunately, during the entire working season of that year, the Ohio river continued at such a high stage as to make it very hazardous, if not impossible, to undertake the task. Meantime all preparations had been made for the erection of the superstructure of the two spans; the false works had been placed in position, and it was decided not to delay or incur any risks upon this part of the work by waiting for a possible favorable opportunity to renew the pier. It became, therefore, necessary to provide for the removal and rebuilding of the pier by a different method.

After a careful consideration of all conditions, it was decided to erect the two spans and rest their adjoining ends upon the old pier, and after removal of the false works, build a strong temporary wooden trestle pier on the outside of and enclosing the leaning masonry pier; lift the ends of both spans of the superstructure clear of the masonry; remove the coping and some parts of the upper courses, place heavy plate girder beams on the temporary wooden trestle pier, introduce strong gridiron pedestals to carry the end posts of the trusses, and after placing cast-iron sand-boxes under the plate girders, where they rested upon the temporary trestle-pier, lower the two bridge spans and carry them upon these supports until a favorable condition of the river would permit us to remove and rebuild the defective pier.

This arrangement is fully shown on the accompanying plan and photographic view.

Two rows of piles were driven on each side of the pier, in the positions shown on the plan; there were 12 piles in each row, or 48 piles in all; they were fitted with strong wrought-iron points, so as to penetrate the riprap which had been placed around the pier

from time to time, and which had become very solid and compact. The piles were cut off at an elevation of 17 feet above low-water mark, double capped longitudinally, cross braced between the two adjacent rows, cross capped by notched timber ties to resist the thrust from the leaning trestle-posts, and two stories of ordinary trestles erected, the inner posts being perpendicular and the outer posts inclined; each story capped longitudinally and transversely, cross braced and bolted. On top of the upper longitudinal caps two solid timber platforms were laid, one on top of the other; on top of the upper platform were placed the sand boxes, which were filled with dry sand after the outflow holes had been closed with wooden plugs; the iron cover lids were placed on the tops of the sand boxes, and the four pairs of plate girders were then swung into position. These plate girders were built of sufficient strength to hold up the two adjacent ends of the two spans of the bridge and the live load passing over them, amounting in the aggregate to about 800 tons. During this operation, however, only one track was used over the bridge, although it was built and is now used as a double-track structure. The plate girders were made 50 feet long, which was longer than necessary for the purpose, but their flanges and webs had to be of such extra dimensions for this work as to correspond to the sizes of a 50-feet span under ordinary traffic, and they could, therefore, be used to good advantage elsewhere, after having served their purpose at the Steubenville bridge.

Meantime the two spans of the bridge had been resting upon the old pier, the coping of which had been partly removed at the time of the erection of the trusses, to make room for the four sets of gridiron pedestals, each composed of eight heavy 15-inch I-beams, connected together by top and bottom plates which had been placed under the end posts of the trusses to serve as copings; these gridiron pedestals were 9 feet long, reaching entirely across the two pairs of plate girders, and the trusses of the bridge rested upon them centrally.

The superstructure of the two spans, whose ends rested upon the gridiron pedestals placed on top of this pier, had been completed in November, 1888; the false works which had served in

their erection, were removed in December, 1888; the pile-driving for the temporary supports was commenced February 16th, 1889, and on April 1st, 1889, the trestles had been erected.

Before the plate girders could be swung into position, the masonry had to be removed as far down as the bottom of the girders; blocks of masonry, however, had to be left standing between the lines of girders to carry the bridge until the plate girders were placed in position. The cutting away of these blocks of masonry was a tedious and somewhat dangerous operation, and we felt quite relieved when the girders had been placed and wedged up under the gridirons so as to carry part of the load, and relieve the remaining blocks of masonry of part of the pressure. This was safely accomplished on June 4th, 1889.

All was now ready to dismantle the pier, but the stage of the river continued too high to admit of the adjustment of the tilted foundation platform, which we hoped to accomplish before starting the new masonry for the pier, and the work remained in this condition until August 6th, 1889, when the tearing down began, and on August 14th, the pier had been removed to the top of the fourth course from the bottom.

An examination of the foundation platform was then made by drilling through the remaining courses at ten points around the circumference of the pier to the top of the timber, when it was found that the western edge of the platform was five inches lower than the eastern edge. The lower four courses of masonry appeared in perfect condition, although, of course, inclined at the same angle as the platform.

The riprap around the pier was found to be very compact, and everything seemed to indicate that it would be safer to let the old platform and four lower courses of masonry remain, and build upon this thoroughly settled foundation, than to tear it all up and start a new one of similar kind, with a possibility of its settlement and a repetition of the former trouble.

Pile-driving for a new foundation was too risky on account of the liability of disturbing the trestle supports which now carried the bridge and traffic.

The new work was therefore started with the fifth course of

masonry, the top of which was trimmed to a level surface on September 5, 1889. On October 10th, the load was transferred from the girders to the completed masonry, and on November 20th, the last piece of coping was laid after the girders had been removed.

There are 860 cubic yards of masonry in the new pier above the fourth course.

The gridiron pedestals remain in the work; but they are concealed by the surrounding coping stone, and the spaces between the L-beams are filled up solid with concrete or Portland cement. The new masonry stands up well, and does not show the slightest indication of settlement.

Exclusive of the plate girders which are now in use elsewhere, this work cost $12,059.84. A good pile foundation under the original pier would have cost about $1500 more than the timber platform; but it would have saved the cost of the rebuilding, and spared us much trouble, anxiety and mortification.

Discussion.

Thomas P. Roberts: I will ask Mr. Becker if any borings were made to determine the depth to solid rock beneath the pier? During the years 1866 to '70, whilst in the government service on the Ohio river improvement, I had occasion frequently to pass under the bridge, and the "lean" of the pier was quite noticeable. Since that time I have frequently crossed the bridge on trains, making such observations as I could, and long ago came to the conclusion that the settling had ceased. I am, however, somewhat curious to learn the nature of the material under the foundations. From my experience in dredging and sounding on the river, I would expect to find in the channel, or mid-river point, in the neighborhood of Steubenville, a coarse gravel and boulder bottom, which is generally compact, and not to be disturbed, excepting by powerful currents. I am well aware that the construction of piers always causes local disturbances and increase of velocity in the current; but upon such a bottom, with ample riprap protection, there is not necessarily danger in pier construction.

M. J. Becker: There were no borings made, to my knowledge, at the time the bridge was built there in 1855, nor in 1862 when the

work was resumed. The indications were that no rock would be found at reasonable depth. In those days the foundations, by means of caissons and pneumatic processes, although perhaps known, were considered entirely too difficult to be warranted under the conditions and circumstances. The material at the bed of the river was, as Colonel Roberts says, composed of coarse gravel mixed with boulders, and quite uniform. It was considered a good foundation, and no doubt would have been a good foundation, if it had not been for the unfortunate lodgment of the corner or side of one of the platforms, leaving an unsupported space underneath, which, when the entire load came on at once, yielded, causing the whole pier above to settle down and tilt over on its side.

I think if the platform had sunk squarely and horizontally on its bottom, there would not have been any difficulty whatever. The other piers are built on similar foundations, and there has not been the slightest movement in any of them. Some of them have been there for 35 years.

William Thaw: Were they built recently for double track?

M. J. Becker: They were built originally on a liberal scale for a single track, and there was no necessity to enlarge them excepting the T-walls on the abutments. With the exception of this masonry on the T-walls, no additional was required on the entire bridge.

Thomas P. Roberts: Was there any coffer dam about the original excavating?

M. J. Becker: No, sir. We simply rigged up a little arrangement around the platform, and pushed the masonry along rapidly so as to be practically above high water by the time we reached the second or third course.

Thomas P. Roberts: There was some current there probably just about that time?

M. J. Becker: Yes, sir; and for that reason we hastened the work as much as possible. We pushed it day and night, and we laid the two courses of masonry, I think, on the ordinary piers in a day or a day and a night, and on the larger channel piers in about two days, the idea being to get down to the bottom as rapidly as possible, and avoid the accumulation of material flowing in.

THOMAS P. ROBERTS: They had some trouble at the Union bridge with the grillage foundations. These were floated into position at rather high water, and they could not keep them in line owing to the anchors dragging, etc. The piers are, therefore, built out of line. All of the bridges on the Monongahela river, built on that plan, have settled a little one way or the other. One pier of the Tenth Street bridge I notice has settled at one end about one foot. It seems to have gone down bodily, but no cracks have disturbed the integrity of the structure, and I presume the settling has stopped. I think, however, it is a defective plan of construction. It is economical, but it is only permissible for comparatively light structures where the material is coarse gravel or boulders, and where at no time the current is excessive.

W. C. QUINCY: I have not had much experience of this kind. We had something like Mr. Becker's Steubenville experience on the Baltimore and Ohio road at Bellaire, at which the foundations were made in the same manner, but the settlement there was uniform. We did not have any trouble such as Mr. Becker refers to.

M. J. BECKER: I will just say that the rebuilding of this bridge in 1862 and 1863 was done by Colonel James Andrews, of Pittsburg, who, later on, improved somewhat upon the method of foundations when he built the St. Louis bridge.

THOMAS P. ROBERTS: In regard to the protection of ordinary bridge piers from erosion and undermining, it is my opinion that not enough attention has been paid to this detail by the engineers of our highway bridges constructed across the Allegheny and Monongahela rivers. These are navigable streams, and steamers "drawing all the water" must necessarily pass close to the riprapping. Under such circumstances there is a powerful "suck" or draught in the current which sometimes rolls away the stones, and certainly capable of washing out all the finer or "bonding" particles of sand between them. This process of washing out the sand intermixed with the riprap may, and does, sometimes extend to and beneath the foundations. Hence results the "squatting" or settlement of the whole mass in proportion to the percentage of solid matter lost. But as we must, from motives of economy, build bridges on this comparatively cheap plan of securing founda-

tions, I have thought it would be the part of wisdom to surround the foot of the slope of the riprap with a line of sheet piling of heavy oak plank, driven as close as possible, and cut off at least two, or perhaps three, feet below low-water mark, so that boats will not damage them. In addition to this precaution, if a foot or more of the bottom of the protection was well grouted, or, better, formed of concrete rammed down, and on top of this the largest kind of irregular-shaped stones, carefully laid, with interstices filled up with long stones, points up, that there would be little trouble. The riprapping of the Ninth Street bridge had to be renewed every few years. It seems to me that the plan I have suggested involves little expense, but the custom has been to dump rip-rap stone around piers with a rather vague idea of its utility. It has been found by experience that it is best not to put a floor in these cribs, but to leave them open so that they can fill the pockets from above, and the cribs will remain perpendicular. The United States engineers now generally build their cribs and ice-breakers without any floors.

W. G. WILKINS: I have had no experience on the Monongahela river, but I had on the Kiskiminetas, out on the Butler branch of the West Penn. We only went down four feet below the bed of the river, two feet of timber and two feet of stone. A great many people prophesied that that foundation would wash out. It went through the flood of the same year it was built; it went through the Johnstown flood, when all the bridges were washed out above and below, and it is standing yet.

At 10 o'clock society adjourned.

S. M. WICKERSHAM,
Secretary.

JUNE 17TH, 1890.

SOCIETY met at their rooms at 8.15 P.M.

W. L. Scaife, President, P. Barnes, Vice-President, R. N. Clark, Director, and 27 members and visitors present.

The Minutes of last meeting were read and approved.

The President presented the recommendation of the Board of Directors that the Committee on rooms be authorized to sublet the rooms now occupied by us, and then to accept the rooms set aside for us by the Society of Arts and Sciences, in the Thaw Mansion.

He also announced that copies of Proceedings in 1889, bound in muslin, can be had on application to the Secretary, by all members whose dues are paid, on the payment of twenty-five cents.

On motion duly made and carried, the Committee on Rooms was authorized to act as the Board recommends.

The following resolutions were offered by Arthur Kirk and, after full discussion, adopted:

HERR'S ISLAND DAM.

Whereas, The United States Government is about to construct, in the Allegheny river, near Herr's Island, in the heart of the cities of Pittsburg and Allegheny, a fixed dam and lock, and

Whereas, A fixed dam at this place will, during ordinary floods which now pass by without damage to any interests, raise the surface of the water several feet, and

Whereas, Above the locality where the dam is to be located there are a number of extensive manufacturing establishments whose grounds and furnaces will be overflowed in case the dam is constructed as now designed, and this several times each year, resulting in great loss of material and the stoppage of works which employ several thousand operatives, and

Whereas, A fixed dam at this place will be liable, by reason of the narrowness of the river and the obstruction of the dam itself, to interfere with the free passage of ice in the annual break-ups of the Allegheny river, in which event, destructive ice gorges attended with immeasurable damage and probable loss of life will result. Therefore,

Be it Resolved, By the Society of Engineers of Western Pennsylvania, while fully recognizing the value of the proposed improvement which promises to extend the limits of the permanently navigable harbor of Pittsburg, that Col. Wm. E. Merrill, of the

U. S. Engineers in charge of said harbor improvement, is respectfully requested to urge upon the government the necessity and importance of adopting for this place some form of movable dam which shall prove no obstruction to the free discharge of the river during its flood periods.

On motion, the Committee on Roads was requested to report in full at the next meeting.

Phineas Barnes addressed the Society, illustrating his remarks on the Blackboard, on "Sundry Rolling Mill Appliances."

R. N. CLARK,
Secretary pro tem.

SEPTEMBER 16TH, 1890.

SOCIETY met at their rooms, Penn Building, at 8.15 P.M.

Present: W. L. Scaife, President; A. E. Hunt, Vice-President; R. N. Clark, and M. J. Becker, Directors; Past President J. A. Brashear, and 45 other members.

A. E. Hunt was elected Secretary pro tem.

On recommendation of the Board, Camille Mercàder, Jas. B. Scott, Alfred R. Davies, and James Ludwig were elected members of the Society.

Report of progress by Committee on Roads was given by T. P. Roberts.

Committee on Rooms reported through William Thaw, Jr., and J. A. Brashear, that we will probably move inside of two weeks, also report of Charles Davis, on same subject to same effect.

Letters from U. S. Department Agriculture and International Electrical Exhibition at Frankfort-on-the-Main, read; also one from Western Society Engineers, Chicago, regarding International Engineers' Congress in 1893. A committee of three to be appointed by the chair to represent this Society.

A paper was then read by E. P. Allen, on Pittsburg and its

resources, which was discussed by Alexander Dempster, T. P. Roberts, M. J. Becker, and J. A. Brashear.

After a vote of thanks to E. P. Allen, the Society adjourned at 9.30 P. M.

A. E. HUNT,
Secretary pro tem.

OCTOBER 21ST, 1890.

SOCIETY met in their new quarters in the Thaw Building.

In the absence of the President, T. P. Roberts was called to the chair, and J. A. Brashear acted as Secretary.

Forty members present.

The following named gentlemen were proposed by the Board for membership and duly elected: M. J. McFarland, Pittsburg; James Foster, Pittsburg; Edward F. Dravo, Pittsburg; George H. Hutchinson, Pittsburg; Charles F. Wieland, Allegheny. A letter was read from President Scaife, referring to the gifts to the Society by Mr. Robert Mannesmann, Alexander Thielen and Dr. Herman Wedding. On motion of Mr. B. F. Jenning, it was resolved to present a resolution of thanks to the above-named gentlemen for their very generous and fully appreciated gifts. Prof. John Langley therefore offered the following:

Resolved, That the Engineers' Society of Western Pennsylvania, hereby tender to Mr. Robert Mannesmann their hearty thanks for the generous gift he has made them in presenting to this Society his very interesting and unique specimens of tubes and other articles made by the Mannesmann process of rolling.

The same resolution of thanks was offered to Mr. Alexander Thielen, for his large collection of tools and other objects, made by the Darby process of recarbonization.

The same resolution of thanks to Dr. Wedding, for the beautiful and valuable drawings presented to the Society. On motion the Secretary was instructed to forward the above resolutions, stamped with the seal of the Society, to the secretary of the American Society of Mining Engineers, who has promised to forward them if sent by October 25th.

On motion of Mr. Reed the Committee on Library was asked to take into consideration the loaning of books to the members who may wish to take them to their homes.

The report of A. E. Hunt, our delegate to the Chicago Engineers' Society, to arrrange for the international meeting during the World's Fair in 1893, was received and read and placed on file. The report is as follows:

CHICAGO, OCTOBER 14TH, 1890.

W. L. SCAIFE,

President Engineers' Society, Western Pennsylvania, Pittsburg, Pa.

Dear Sir: I herewith respectfully have the honor to report to you that I attended the meeting held at the Western Engineers' Society Rooms, Chicago, at 10 A.M. October 14th, as a delegate of the Engineers' Society of Western Pennsylvania, as well as a delegate from the American Society of Civil Engineers, and from the American Institute of Mining Engineers. There were thirteen societies represented, including all of the national societies in the meeting. Mr. E. L. Corthell called the meeting to order, and after explaining the object of the meeting Mr. Octave Chanute was elected Permanent Chairman, and Mr. John W. Weston as Secretary. It was resolved that a committee of seven, of which the chairman of the committee should be one, should be appointed by the chair to propose a plan of action regarding a headquarters for the various engineering societies at the World's Columbian Fair, to be held in Chicago, in 1893; also at the time of the World's Fair, to hold an International Congress of engineering societies, at which papers of interest to engineering should be read. The committee of seven consisted of Mr. Octave Chanute, Mr. E. L. Corthell, Mr. William P. Shinn, with Mr. Strobel as alternate, Professor Johnson, Mr. Don Whittemore, Mr. Jesse Smith, and W. W. Curtis. A plan of action proposed by Mr. Corthell was discussed at the meeting, and was as follows:

1. To have a Joint Engineering Headquarters in Chicago during the six months of the Exposition. The question of whether the headquarters should be in the Exposition grounds or more centrally in the city was left for further consideration.

2. A staff for the joint societies of a permanent Secretary with

two assistants, at least one of which should speak the various European languages, should be appointed.

3. A rendezvous should be proposed at this headquarters for the various engineers of the United States in visiting the World's Fair, and also of any foreign engineers who should come here.

4. The duties of these staff officers should be to give information with reference to various engineering matters in the Exposition, to give information with regard to matters in the country to foreign engineers, to give letters of introduction to the various persons who are in charge of important engineering enterprises, to keep a record of the business of the joint meetings, and also of the engineer visitors to the headquarters, and to provide them with invitations to meetings. It is estimated that the cost of this staff and the headquarters would be defrayed by a subscription of one dollar per member from each of the engineering societies. To this fund also would be added a larger fund from the various manufacturing and other industries allied to the engineering profession.

5. To hold a Joint International Engineers' Congress to occupy days, presumably something like a week's time. This congress to use the English language at its sessions. That there should be one joint session at the opening, and one at the end of the sessions. The remainder of the time of the meeting the various delegates should divide into chapters upon their various subjects to be discussed. The subjects so far proposed were as follows:

Railroad Engineering, Hydraulic Engineering, Bridge Engineering, Steam Engineering, Marine Engineering, Military Engineering, Mining Engineering, Mechanical Engineering, Surveying, Electrical Engineering, Sanitary Engineering, Municipal Engineering, Materials of Construction, Geology and Metallurgical Engineering.

6. All papers for these sessions to be submitted beforehand to an examining committee to report upon the advisability of having them go before the session, and the papers to be distributed at the session or before to the delegates and then read only by title, so as to allow the entire time of the sessions for discussions of the paper. These papers to be upon novel inventions in actual use, descriptions of new tools in actual use, descriptions of new machines in

actual use. It is proposed to have the joint committee also choose a list of subjects for discussion. This data as elaborated at the meeting was placed in the hands of the Executive Committee of seven, with authority to report at an adjourned meeting upon Wednesday, October 15th. As Mr. Shinn and myself, the two Pittsburg delegates, were obliged to leave with the Iron and Steel Institute excursion on Tuesday night, we were unable to be present at the second session. We, however, represented our societies in the first session of organization, and saw that the societies we represented were formally added to the list of societies taking hold of the matter, and also for an arrangement that the secretary of the committee should send a printed letter with the official action of the society to the secretaries of each of the societies represented.

Yours respectfully,

ALFRED E. HUNT,

Delegate from Engineers' Society of Western Pennsylvania, and Vice-President.

Prof. Langley then read his paper, viz.:

EUROPEAN BESSEMER PRACTICE IN SMALL CONVERTERS.

IT is well known that one of the features which distinguishes the Bessemer process from all other methods of making steel is its compactness and large output from a plant covering only a comparatively small area. It is pre-eminently a rapid operation, and this element of high speed characterizes it generally, and in this country almost universally, in all its details. Rapid blowing; prompt recharging of the converter as soon as a heat has been found; ingots swung out of the casting pit the instant danger of "bleeding" is over; usually a double set of cupolas and vessels, in order that blowing and output may not cease a single hour while repairs are going on; the mill on day and night turn. Everywhere speed made the primary consideration, so that one might almost regard the converter as a mere pocket or enlarge-

ment in a pipe through which a stream of melted iron is passing from the cupolas to the molds, this stream not being strictly continuous only from the necessity of arresting it periodically for a few minutes to inject air into it. These are the conditions under which the Bessemer process is usually operated, and which are considered to be those on which pecuniary success depends.

But there are cases when these elements of high speed and large output may be actual drawbacks, because other objects or conditions interfere with them. For instance, in the case of an iron foundry to which a steel casting plant is to be added, where a large number of small objects is to be made, such as wheels for trucks, or parts of agricultural machines, the diversity of articles and the large number of molds requires that the steel shall not be brought to them in fluid masses of five or ten tons, but gradually in quantities of a few hundred pounds only. Or, as a second illustration, suppose a blast-furnace at a distance from others or from a large industrial centre, and let the owners of the furnace desire to make Bessemer steel; unless their stack is a very large one it could not supply the fifteen to twenty tons an hour, which a converter of the usual size would consume.

Thus it may be conceded that abstractly speaking small converters are desirable, and that there would be a large field for their use if they could satisfy only a moderate requirement in the way of economical production. That they can do so under special circumstances facts have already shown, for the two supposed cases just cited have their counterparts in European practice to-day, and are typical of the two classes of cases, namely, steel foundries and small blast-furnaces.

The conditions of pecuniary success then, are first, for foundries the manufacture of a large number of small or special shapes, to be cast in dry sand molds, where a higher price per pound will cover the increased cost of Bessemer steel that has been made in small quantities at each blow; and second, for isolated blast-furnaces making a high grade of pig when the superior quality of the steel produced will enable it to compete with the cheaper rail and structural steel of large plants.

During the summer of 1888, the writer visited a number of

European establishments using small converters, and the following is a brief account of their distinctive features:

In France Monsieur Robert had just brought out a special side blow converter, for which he claimed several original features; also it was alleged that very surprising technical and commercial results could be obtained by it. The process had just been installed in a foundry near Montmartre, in Paris, under the direction of Mons. Robert himself. At the time of my visit the plant consisted of a single converter, a cupola, and a casting floor of about 2500 square feet. The construction of the converter and the management of the blow were so similar to the practice which I afterwards saw in Belgium, that its description may be deferred for the moment. A sample of metal taken directly from the vessel was forged under a small power hammer to a bar one inch by one-half inch. It was very red short, and would not stand bending hot to more than fifty degrees from the axis of the bar without cracking. When broken cold its fracture was dirty and granular, and apparently indicated a metal about half way between cast and wrought iron.

It is only fair to Mons. Robert, however, to say that the plant had just been installed, was confessedly working imperfectly, and that information since received from parties who have purchased the right to use this method, contains the report that a fair quality of soft steel can be made by it.

In Belgium the small side blow converter was in successful operation at the works of Mons. Cambier, at Marcinelle, near Charleroi. This gentleman gave me every opportunity for investigation, even to showing his records of charges and yields, and a full set of drawings. He claimed to be working under the Belgian patents of Walrand, and thought Robert's process to be identical with Walrand's.

It would be out of place here to enter into any discussion of the priority of these two inventors. What was obvious, however, was that the Belgian operator had been using the method for over two years, and was about to double the capacity of his plant by putting in a second vessel.

The Walrand converter has a capacity of about a ton, and has

externally the shape of a cylinder terminated by a truncated cone; its cross section is D-shaped. On one side a short distance above the bottom there is a rectangular wind-box provided with six glass covered peep holes.

Inside, the vessel is lined continuously on the sides and bottom, for the latter is not made removable. Opposite the wind box and about twelve inches above the bottom lining are a number of rectangular openings or tuyeres for the admission of the blast. These tuyeres do not pass through the lining either radially or tangentially, but are pointed midway between the two directions, making an angle of about thirty degrees with a radius in a horizontal plane and an angle of thirty to forty with the same radius in a vertical plane. The effect of this is said to be that the blast penetrates deeply into the metal, and at the same time gives the latter a rotary motion around the vertical axis of the vessel, thus bringing all portions of the melted pig successively in front of the tuyeres.

The converter was mounted in a low frame, which barely permitted it to swing clear of the floor. Two geared wheels connected the trunnion of the vessel with a large iron windlass wheel on the side of the fixed frame, so that four men were able to turn the converter down or up. The management of a *blow* was as follows: The vessel was turned on its side and about one ton of metal was poured in from a ladle. It was then put in an inclined position and the blast turned on, then it was very gradually brought up to the vertical and blown for twelve minutes. It was now turned down nearly horizontally and the slag run off. Then a man standing in front threw in by hand lumps of cold ferro-manganese, which he tried to distribute evenly over the surface; then there was an interval of about five minutes in which everybody took a rest, some of the men lighting their pipes. This leisurely proceeding was in marked contrast to the activity which follows the termination of the blow in American practice.

On looking into the open mouth of the converter I could see several lumps of ferro which had lodged in the slag on the sides and would not melt, so that this would appear to be an injudicious method for putting a definite amount of manganese into the metal.

At the end of five minutes signs of life became apparent. Small ladles holding about two hundred pounds were brought up to the mouth of the converter, and were filled successively by the men at the windlass who tipped the converter carefully. These ladles were each taken by two men to the sand molds on the floor, the entire operation of filling the ladles and pouring the molds being precisely like the usual practice of an iron foundry.

In several instances the ladles filled with steel were allowed to stand several minutes on the floor before pouring, because the metal was too hot.

This entire freedom from the evils of premature chilling was a great surprise, and I think would be so to any one familiar with the customary behavior of Bessemer steel. The explanation appears to be two-fold; first, from the composition of the metal which was, at the time of my visit, about 0.40 of carbon; thus the melting point is materially lower than for soft steel of the customary composition; second, the side blow converter certainly maintains a very high temperature, doubtless owing to a portion of the blast always playing over the surface of the bath. Heavy brown clouds of burnt iron appeared almost at the beginning of the blow, and grew increasingly prominent to the end.

As to the economy of the operation the losses in the converter by oxidation are said to be fully twenty-five per cent. The metal made at Marcinelle was fairly soft and tough. I inspected some fifty wheels after they had been bored and faced and saw only a small proportion of blow holes. Mons. Cambier says he has no difficulty in making any carbon between 0.20 and 1.00 per cent. He was so well pleased with his two years' trial of the Walrand process that he was then building a second converter.

The second head, small converters near detached blast-furnaces, finds its principal illustration in Sweden. There the conditions are quite peculiar, namely, remarkably pure ores, very cheap labor, and only charcoal for a fuel. The only salvation for a Swedish iron-master is to make high quality the first consideration; everyone knows how well they have succeeded in their pig-and bar-iron, and they have done equally well in their steel practice, for it is quite generally conceded by European makers that the Swedes

have brought their Bessemer steel up to the very highest quality this type of metal is capable of attaining.

Owing to the complete lack of native mineral fuel, and to the large number of rivers, the iron establishments are always located at some source of water-power, and so numerous are these little forges and furnaces that, wherever the scenery is particularly wild and pleasing, there one is sure to find the manufacture of iron going on in some picturesque collection of wooden buildings which detract little or nothing from the landscape, because there are no mountains of slag and ashes to cumber the ground and no smoke to poison the air.

Of the many establishments in Sweden I will select two, one as makers of low steel and the other of high.

At Avesta, on the river Dal, at the site of a splendid water-power, are located a charcoal blast-furnace and a very curious small Bessemer plant; perhaps it is the very smallest in the world. The steel made here is nearly dead soft, and is used principally for galvanized sheets of exceptional quality. The converter is only a few feet from the base of the blast-furnace, and so placed that the metal can be run directly into it without requiring a ladle. The shape of this converter is very peculiar; externally it resembles a barrel about six feet high by four in diameter; there is only one opening in it which is placed on the side just below the top, and is only six inches in diameter. The bottom is removable in the usual way. By this plan the flame issues at right angles to the vessel when the latter is vertical. To charge it the converter is turned till it is nearly standing on its head; rather less than one ton of pig is run in directly from the blast-furnace, and the converter is turned up and blown. The pressure of the blast is eighteen pounds.

By having such a very small throat the flame issues in the form of a blow-pipe and with a deafening roar. The progress of the decarbonization is very sharply indicated by the changes in form of the flame which gradually shortens till it just hovers around the mouth of the vessel. This indicates about 0.10 per cent. of carbon, and is the point aimed at. A few lumps of ferro-manganese are thrown in by hand and stirred with an iron bar. At

the end of three minutes a slight reaction is apparent. The vessel is now turned over and poured, slag and all, into two ten-inch molds, and the latter are purposely slightly overflowed in order to carry off the slag.

In the above practice it will be noticed that no recarbonizer is used. The metal is blown *down* to the required carbon and then the process is arrested. This is universally the case in Sweden, and is in marked contrast to the customary American and English practice, the Swedes always aiming to stop at the required carbon, but never to overpass it. The theory of the very small throat is that by causing a back pressure in the upper part of the vessel the temperature of combustion of the metalloids is raised, and thus a higher heat is obtained; also that less metal is mechanically projected by the blast. However this may be, it seems to be pretty well established that the long, sensitive, flame, with its inner cone and outer mantle, is an aid in judging of the progress of the decarbonization.

At Sandvigan, a very high grade of steel is made, both in the open hearth and by the Bessemer process. Nearly all of the metal produced in the latter is high carbon steel, which is used largely for tools. Probably no material of its type stands higher; it is said to nearly approach crucible steel in quality. The converter has about three tons capacity. The iron is brought to it in a ladle through an underground tunnel from a blast-furnace in the vicinity. The converter is of the customary form, but has only a seven-inch opening at the throat.

If, for example, 0.80 carbon is to be made, the blowing would be stopped when the flame indicated a close approach to 0.90. A sample is then removed by a hand-ladle and cast into a test ingot which is removed as soon as it has set to a small power-hammer and forged into a bar of about one-half by three-eighths of an inch. This forging can be done in twenty-five seconds. The bar is now ready for the mechanical carbon test, which is made by heating it in a charcoal fire till it is near its melting point and then hammering it. At this temperature high steel is of a sandy texture, almost without cohesion and readily crumbles under the stroke. A bar of known composition is sometimes used as a standard, with the

trial one. The higher the carbon the lower is the temperature at which the steel crumbles. The test is made very quickly and seems to be fairly accurate, for several Swedish steel makers told me that an experienced smith could determine the carbon within from five to six points, provided that the metal was pretty uniform in its other constituents.

In the supposed case at Sandvigan, if the smith reported, say, 0.95 carbon, the converter would be turned up and blown for a few seconds longer and then either poured or sampled a second time according to the degree of uncertainty present, no ferro-manganese being used.

As an example of actual practice, here is the analysis of the pig and steel made from it, taken from the books in the office at Sandvigan:

	Pig.	Steel.
Silicon,	1.10	.066
Manganese,	3.08	.437
Graphite,	3.68	——
Combined carbon,	.78	1.20
Phosphorus,	.015	.022
Sulphur,	.014	.01

In regard to the apparent removal of sulphur it should be noted that the analysis is of an average of the pig, while that of the steel is on an individual blow.

The low silicon and high manganese is quite general in Swedish practice, for it is forced upon them by circumstances. The low temperature of their small charcoal blast-furnaces produces low silicon pig, and consequently a deficiency of heat in the converter; to make up for this, iron-ores carrying this element are used, or even manganese-ore may be charged into the blast-furnaces. As a necessary consequence, by having enough of this element in the pig a proper quantity can be left in the steel at the end of the blow without the necessity of using ferro-manganese or spiegel.

The differences between the Swedish and the customary methods of Bessemer practice are that by the former there is less loss of iron by oxidation, and it is claimed a more homogeneous metal is pro-

duced; but also it is conceded that the difficulties of hitting the carbon desired are considerable, while by the method of recarbonizing these difficulties are greatly lessened, and a much greater speed of working can be attained.

Obviously, the conditions of commercial success for small converters are quite special, and are limited to those similar to the Swedish, where exceptionally pure ores and low-priced labor permits slow working, and quality, rather than quantity, to be the chief aim of the steel maker.

In the course of his paper Mr. Langley made the following observations:

This paper is not so much directed to theory, or to giving a large number of statistics, nor is it addressed to those members particularly who are versed in the details of American Bessemer practice. It is rather a descriptive or narrative paper than one of a strictly professional character. It occurred to me that it would be interesting to give an account of some of the peculiarities of the European practice in small converters, because, while there are no very small converters in operation in this country, yet in certain respects the European practice leads that of all the rest of the world. I mean the Swedish practice in the matter of quality.

In explanation of a drawing of the Walrand converter he said:

The metal is also in rotation around a vertical axis. The force of the blast is intended to keep the metal in an inclined position, but even if the drawing is somewhat exaggerated it is evident that there is an enormous area of contact between the incoming blast and the iron. It is quite unlike the ordinary converters where the blast bubbles up through the metal, because in the ordinary converter the blast in passing through the metal meets its carbon and its silicon in excess, but here the blast being blown on the top of the metal the superficial stratum of carbon and silicon is oxidized almost immediately, and the action is expended upon the iron.

In speaking of Swedish practice he said:

Now, by the method I have described, two results are obtained. One is that the flame instead of issuing in a large blaze has almost precisely the character of a blow-pipe flame. It has a dark mantle like that of a Bunsen burner. At the commencement of the blow

the flame is of course very short, but as soon as the carbon reaction sets in there is a cone seen hovering about the mouth of the vessel. It grows longer until it has proportionately the outlines of the sketch. Now as the carbon begins to burn out we have in our ordinary practice no means of telling the rate at which the carbon is burnt out. We can look in our spectroscopes and we can get every tint of the flame, but when the carbon goes out it goes like a flash. The Swedes desire to know the rate at which the carbon is leaving the metal because they do not blow all the carbon out. They blow down to the carbon they want to get and then stop. By this arrangement the rate at which the carbon is going out can be told by the form of the flame.

At the time of my visit of course I was quite inexperienced in that particular flame, but even inexperienced as I was there was no difficulty in seeing that there was a very close connection between the burning out of the carbon and the appearance of the flame. After the maximum is passed and the carbon begins to disappear, of course this flame begins to shorten, and shortens with great regularity until the carbon is reduced to ten points. The inner flame is just hovering over the mouth of the vessel and the dark mantle has almost entirely disappeared, leaving only a little flickering flame. They say by the shortening of the flame they can tell the disappearance of the carbon far better than by the customary English and American practice of watching each tint of the flame.

Another result which they find of great service to them, and this I must take entirely upon their report, for I have no means of confirming it, is that they have a very high temperature in these small vessels. There is a less total generation of heat than in our large vessels, and the ratio between the volume and the surface is, of course, very different from that of a 5-ton converter. Therefore the Swedes are continually fighting against the danger of chilling. They say by having the aperture of the throat reduced down to about six inches they get a much higher temperature, and apparently they do. The theoretical explanation of that may be found in the fact that the higher the pressure the greater the temperature of combustion, and, therefore, the Swedes have the theory, and claim to have the practice as well. The result of this throt-

tling is to produce a terrific sound, the most deafening I ever heard.

I had every opportunity to witness the mode of making carbon tests. The test-bar is taken to the forge and placed in the fire side by side with a second bar of precisely the same shape and cross-section in which the carbon has been determined by the chemist. Then the two are brought up to a welding heat. Now, high carbon steel at a welding heat becomes sandy and mushy. The two bars are taken by the smith, laid across the anvil and struck a heavy blow with the hammer. The steel is in both cases mushy, and flies off like so much semi-melted sand. At the second blow it does not fly so rapidly, at the third it is more ductile, and at the fourth or fifth it becomes very ductile. The number of blows necessary to strike before it ceases to fly around the shop is a very good indicator of the amount of carbon the steel contains. Certainly according to their statements they can determine the carbon very closely. That the carbon can be determined very closely by this means I was able to prove by experiments made in this country. With a little care and skill a man can hit the carbon within 15 points on high carbon steel, and I have no doubt that a man who would give much time to it could determine within five to ten points.

At Sandvigan, they allowed me access to some of their books at the office. They seemed to have no unwillingness at all to tell everything they were doing, They allowed me to copy from their books as many analyses as I cared to. I will only give you one, and I quote this with this confidence that it is not a selected example. I went to their large office ledger and was allowed to turn over page after page at random and copy analyses. Therefore, this shows regular work at Sandvigan, and is the analysis given in the body of the paper.

One is struck with the peculiar composition of the pig. The silicon is remarkably low. In this country we could not blow pig containing as little silicon as that. You will notice the manganese is quite high. This explains the peculiarity of their practice. The reason why they do not have to use any ferro is also apparent. This very high steel was stopped say at 1.20 carbon. By

that time the original 3 per cent. of manganese had burned down to .43, which is a very fair quantity. If they had been blowing lower than that the manganese would have been somewhat lower, but in no case in their practice do they permit the manganese in their pig to get so low as to blow out before the carbon burns out.

They attribute the high quality of their metal, which is unapproachable by Bessemer metal made anywhere else, to this. They say in our practice the quantity of oxygen introduced is so great that the manganese never perfectly takes it out again, and, therefore, the metal is never perfectly homogeneous. By their system it must be homogeneous.

Certainly, whether their theory is correct or not, we know their metal stands very high indeed. It is obvious, at the same time, that this practice, with a specially obtained pig, and blowing down very leisurely, is one that could only be commercially successful under some such conditions as exist there, namely, very pure ores and pig, and a steel which brings a fancy price in the market.

Discussion.

A Member: I would like to ask Mr. Langley how they handle the iron coming from the blast-furnaces. He speaks of the very small quantity they charge into the converters at one time, and the very leisurely manner in which they handle it after coming to the converter. And I would also be interested in learning how they handle the steel when it was poured from the converter.

Prof. Langley: The converters are near the blast-furnaces, which are very small. The metal is usually run in the ordinary way. The ladles are much like ours.

The other part of your question reminds me of a point. At some places they employ what is called a converter-ladle, but quite a different thing from the French converter-ladle of which I first spoke. It is not usual in these small vessels to attempt to use a ladle at all. The molds are brought right up to the mouth of the converter if possible. But at one or two places I saw the following device used, which permits the steel to be poured without introducing the slag into the mold. This special device I first saw at Nykroppa, where they make a specialty of 1.50 carbon steel,

running that out into 14-inch ingots. The converter here contains, if full, about three tons, but they do not charge much more than a ton and a half. It is the usual pear-shape form of a vessel, but the neck is very short and very wide indeed. Apparently this was 18 inches in diameter. Now that appears quite opposed to Swedish practice, but we find this lined up so that the opening is only 7 inches. Great pains are taken to make the bricks very true, lying accurately within the plane of the converter mouth. The ladle is detached wholly from the converter during the blow, is warmed by a small charcoal fire; then, at the end of the blow, the converter ladle is brought up against the mouth of the vessel. There are lugs which I have not shown in the sketch, the joint is covered with fire-clay and then by a hydraulic arrangement it was forced up against the mouth, and the ladle and the converter are practically one vessel. In tipping down, the steel will run into the ladle but the slag is left behind in the vessel. The ladle being a part of the converter cannot be carried about, and the molds must be brought to the ladle. They are mounted in an apparatus like a large umbrella-stand rotating around a central pivot. When I was there, they had six 7-inch molds in this umbrella-stand, which was sunk into a pit below, and by rotating, the molds are brought under the ladle and filled in the usual way.

A MEMBER: What was the interval between the charges?

MR. LANGLEY: From fifteen minutes to half an hour.

MR. BRASHEAR: I would like to ask Prof. Langley if he saw many of the castings from these small side-blow converters that were turned and worked afterwards. Did you notice particularly that they were more free from blow-holes than the castings we are having now from Bessemer? The best castings I have seen in this country are from Chester. I am thinking now of having some very fine castings for some large objectives, in which the co-efficients of expansion and contraction are practically the same, and we find very great difficulty in getting such things free from blow-holes.

MR. LANGLEY: I prefer not to say anything at all about American castings, but I compared these castings made at Marcinelle,

with a great many other castings which I afterwards saw in the great machine shops in Saxony, where they are using steel from all parts of Germany, and certainly the blow-holes in the Saxon steel were very much larger and more numerous than in the small works at Marcinelle. Whether that would be so everywhere I cannot say.

A MEMBER: It appears to me that the first process mentioned by Prof. Langley is very much like our Clapp-Griffith. The facts I take it are much the same. We get a high heat with apparently low silicon. In our ordinary Bessemer practice we take advantage of this fact that iron is oxidized by a very small amount of blast through the tuyeres and in turn brings up the heat. We do not like to do it for there is an enormous waste of iron; but in some cases it is necessary.

These high heats I may say that in ordinary steel for rolling, it makes a very poor steel. It does not roll well and is usually hard and brittle, but for this particular purpose it would be necessary, of course, in pouring it for small castings.

There is one advantage that we see that the silicon is brought down, whereas in ordinary practice in getting a heat that is high, the silicon would also be high. But in the rolling of steel the enormous waste that would be entailed by that method of blowing in the ordinary converter makes us avoid that method. Speaking of the low silicon of the Swedish practice we find that it would be impossible in using cupolas to blow metal with so low silicon, but where we take the metal directly from the blast-furnace where the initial heat is high we find we can blow with silicon even lower than 1.10.

Referring again to the converters where the steel is made for castings, I should think from looking at that analysis that it would be much cheaper to make it in the open hearth rather than having the great oxidation of the Bessemer converter, and be able to control it much better.

MR. ROBERTS: I should think from your description of that one converter where the blast is directly on the surface that from the revolving movement it would bring all the metal in contact with the blast very rapidly.

MR. LANGLEY: The shape of the metal in the vessel I know nothing of from personal observation.

A MEMBER: You spoke of hammering 14-inch ingots of 1.50 carbon. For what purpose was that carbon used, do you know?

MR. LANGLEY: I think they hammered them down into 14-inch billets and sold them to the Sheffield steel makers.

After which Society adjourned.

J. A. BRASHEAR,
Secretary pro tem.

NOVEMBER 18TH, 1890.

SOCIETY met at their rooms.

Meeting was called to order shortly after 8 P. M. President Scaife in the Chair, Vice-President P. Barnes, Director Wilkins and twenty-seven members present.

On motion T. P. Roberts was made Acting Secretary, whereupon the minutes of the October meeting were read and approved.

The President read a letter from S. B. Fisher, resigning his membership in the Society owing to his permanent absence in the west.

The following applicants having been favorably reported upon by the Board were duly elected members of the Engineers' Society of Western Pennsylvania:

Harold E. Stowe, Benjamin Page, J. Everett Lobingier, Alfred Randolph, Peter Doxrud.

Charles Davis reported that the Library Committee not having met during the month, no action had been taken in regard to members being permitted to take books from the library. T. P. Roberts reported that there had been no meeting of the County Road Committee, though the Committee expected to report later on matter for the action of the Society.

President Scaife read at length an interesting report of the convention held in Chicago, October 14th and 15th inst., to consider the establishment of an engineering headquarters, and the

holding of an International Congress of Engineers during the World's Columbian Exposition, 1893. Captain Alfred E. Hunt, delegate from this Society, not being present, the debate upon the report was, on motion, postponed until next meeting of the Society.

Charles Hyde then read the following paper, illustrating his remarks with diagrams on the board, and with blue prints.

HYDRAULIC MILL APPLIANCES.

THE underlying principle of hydraulics discovered by Archimedes, viz., that pressure applied to a fluid acts equally in every direction, is one that has been of very great importance, and of very general application of recent years in the arts, and has nowhere been more generally used, nor with more advantageous results, than in the manufacture of steel.

I propose briefly to call the attention of the association to one or two recent developments of hydraulic appliances, which may probably be of interest to most of our members, and which I trust will lead to discussion of benefit to every one.

I may state here that these appliances have been introduced by engineers well known in this district, and some of which appliances are at present in operation in Pittsburg and vicinity. I take these as being more familiar to myself, and as likely to be of more interest to this association.

Turning first to the casting department connected with either the Bessemer or O. H. process, as coming first in the line of conversion of the raw material of the mill, into a finished product and passing over the hydraulic cranes, hoists and turning arrangements as being familiar to every one, I should like to call your attention to an ingenious arrangement for quickly and easily, stripping off the moulds from ingots, combining as it does, the lifting of the ordinary crane with the thrust of the ingot extractor in one operation, so that in no ordinary case of sticking need the ingot and mould be lifted out of the pit, or off the car. together.

The general outline of the machine is illustrated in Figs. 3 and 4, page 142, and the whole operation is controlled through a

system of levers by one man who is well away from the heat of the ingots.

Preferably the ingots are cast on cars, two on each car, and run underneath the track on which trolley carrying the extractor travels.

Three pipes connected with different parts of the machine by means of swivel joints, give the various movements required to obtain the desired result, one pipe leading to the cylinder above the piston 6, a similar pipe leading to the cylinder below the piston 8, and the third pipe connecting with the space between the pistons by means of a pipe fixed to and passing through piston 6, and which pipe slides up and down inside the tube 21, thereby keeping the connection open, no matter in what position the piston may be.

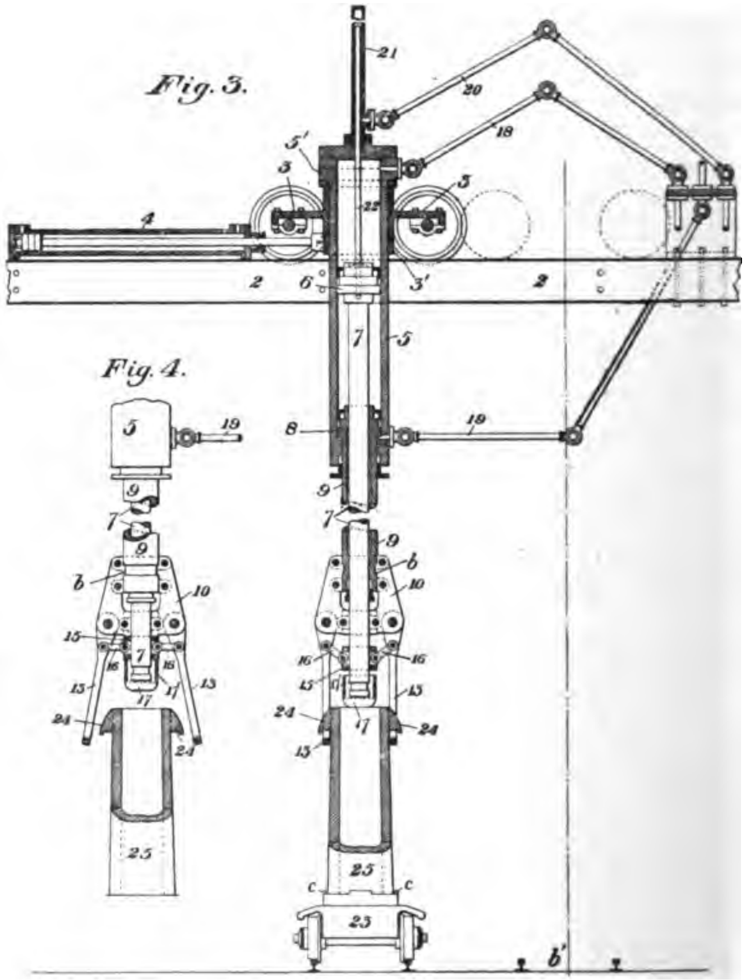
Assume now that a cast has been made and the buggies run within the range of the machine. The trolley is moved if necessary, until the ram of the extractor is directly over the ingot to be stripped, the rams 7 and 9, having been previously raised to a sufficient height by admitting water through pipes 19 and 22. The centre ram is raised independently of the outer one (through which it slides) by the admission of water underneath piston 6, and by the act of rising, opens, by means of the toggle joints, the links suspended from the outer ram, until the collar carrying said toggle joints strikes against the under side of ram No. 9. When the areas of the pistons above and below being equal the two rams remain balanced, and form, owing to the water between them, practically one ram.

Water admitted now below the piston No. 8, would raise the two rams together, carrying up the links open as shown in Figure 4. This would represent the position when the buggy carrying the ingot was run underneath.

By exhausting the water from pipe 19, the rams now descend until the links still being open, are opposite the lugs on the mould, then by exhausting the water from the space between the pistons, the inner ram falls by gravity, and in doing so allows the collar to fall, which draws in the links against the side of the mould, so as to fit under the lugs in the manner shown.

The connection of the links by toggle levers with the collar serves to equalize the motion of the links, and to cause them to

H. AIKEN.
MILL APPLIANCE.



close symmetrically upon the mould, the operation of engaging the links being entirely automatic.

The valve in pipes 18 being now closed so as to confine a body of water above the piston 6, to prevent it rising, and the valve in pipe 20 being open to exhaust, the valve admitting water below piston 8 is opened causing the outer ram to rise, carrying with it the yoke and links, and as the links are connected with the mould, and the ingot is prevented by the centre ram from rising, the mould is stripped from the ingot, leaving it standing upon the car whilst the mould can be swung round and deposited automatically upon the ground, or upon another car.

Should the pressure upon piston 8 prove insufficient to effect the stripping, owing to the ingot sticking, water may be admitted through pipe 18, into the top of the cylinder, when the whole sectional area of the cylinder comes into effect and the cylinder itself rises slowly in its socket in the trolley, carrying with it the piston 8, and the ram, links and mould attached. As soon as the initial frictional resistance is overcome, the water may be shut off the top, when piston 8 will continue to rise and coming in contact with the upper piston will raise the inner ram from the ingot.

To deposit the mould, the pipe below piston 8 is opened to the exhaust, and the mould lowered by gravity upon the ground or a car, as the case may be, and the disengagement of the links is effected by admitting water through the upper pipe into the space between the pistons when the inner ram rises, and its shoe coming in contact with the collar causes this to rise and push out the links into the first position, when the machine is ready to take hold of the next ingot.

The apparatus thus affords an efficient means of extracting ingots without any subsequent handling of the ingots or moulds, and can be operated much more rapidly than it can be described, and when it is stated that two ingots may be extracted simultaneously it is at once apparent that the device is as effective as a time and labor-saving appliance as it is ingenious in its construction and design.

The apparatus may be carried on the jib of an ordinary crane, or suspended in any way most convenient or desirable to suit the particular condition of any given case, as it is entirely self-contained and free to move in any direction, the connection being maintained by means of suitable flexible or jointed pipes.

Feed Tables for Rolling Mill.

Had time allowed it was my intention to have discussed one of the most successful hydraulic methods of charging and drawing ingots from the re-heating furnace, in connection more particularly with plate-mill work, but, if agreeable to this Society, that, with several other interesting appliances, can be treated at some future meeting more fully than was possible to me on this occasion.

Assuming, however, that our charging and drawing has been properly taken care of, a novel arrangement in mill tables, lately introduced by Mr. Aiken, will probably prove of interest and repay a short investigation.

The system may be applied to the rolling of plates, rails, structural material, etc., but I propose to consider it more in detail as applied to the rolling of plates where two stands of rolls are used, one for breaking down and one for finishing.

The system consists briefly of the ordinary feed tables, composed of rollers carried in side pieces, and driven by bevel gearing, the whole table, and this is where the novelty and the special advantage of the system comes in, being carried bodily on the jib of a crane, hydraulic preferably, and capable of being raised and lowered to suit the forward and back passes of the mill, and also capable of being swung round to the next pair of rolls, where the table can be raised and lowered as before. The platform of the crane is so arranged on the jib as to carry round with the tables the engine for operating the same, the hydraulic cylinder for operating the manipulator, the necessary valves for controlling the various motions, and the one man necessary to operate the whole.

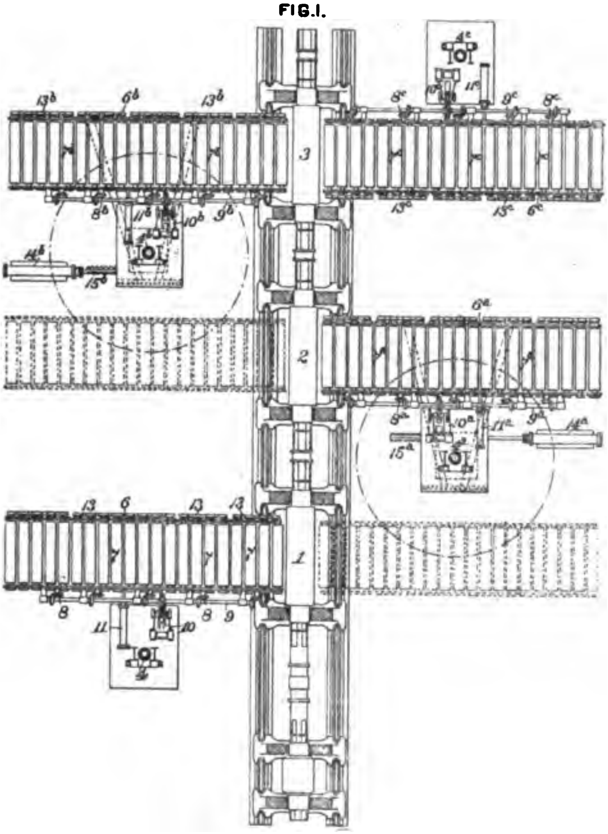
Assuming now that an ingot has been placed on the table opposite the roughing-down stand, the table is raised or lowered, as the case may be, to suit the direction of the rolls, and the rollers set in motion in the usual way, the rollers on either side being rotated in the same direction.

The pass having been made, the tables are adjusted to the proper position for the return pass, and the direction of the rollers reversed. When sufficiently broken down the ingot is swung round on the table to the finishing-stand of rolls, where the same

process is continued till the plate is finished, when the tables may be swung round into a position parallel with the roll-train, or approximately so, and transferred to a line of cooling or transfer-tables.

H. AIKEN.
FEED TABLE FOR ROLLING MILLS.

FIG.I.



In cases where three stands of rolls are used the cranes might be arranged as shown in the accompanying sketch, where tables 4 and 4c are adjustable vertically only, and tables $4a$ and $4b$ are adjustable vertically, and also capable of being swung round into line with stands 1 and 2 and 2 and 3 respectively.

In this case the ingot, after being roughed down on stand No. 1, is swung round to stand No. 2, and after being rolled down, or shaped still further on stand No. 2, it is transferred to No. 3, when tables 4 and 4*a* are in a position to take hold of another ingot, which can be roughed down whilst the previous one is being finished on stand No. 3, so that less time is lost by any part of the mill remaining idle.

Another arrangement of the tables may be made, where three or four stands of rolls are used, whereby the tables may be swung into line parallel with the train of rolls, forming a continuous table, by means of which the ingot may be transferred from No. 1 stand to No. 2, 3 or 4 at pleasure, and as any one of them, or all of them in turn, may be still further reduced or shaped.

Still another arrangement of the tables may be made, in which the tables are divided, the section next the rolls being pivoted near the end farthest from the rolls, and raised and lowered at the end nearest the rolls to suit the forward or back pass, whilst the outward section of the tables would be capable of vertical adjustment and also of being swung round from one stand to the other as before described, thereby acting both as transfer-tables, and also as serving to lengthen the feed-tables.

The ingot might by this arrangement be broken down on stand No. 1, and, when becoming too long for tables No. 1, be transferred to tables No. 2, where it would be finished, whilst during this finishing process a fresh ingot would be placed upon tables No. 1 and reduced ready for transfer, thus making the operation continuous.

The foundation work required for tables of this type is very small, and the floor space under and around them can always be kept clean and tidy, a point of considerable importance with an orderly and careful mill manager.

The methods of admitting water to these table cranes for operating the various cylinders is an interesting one, as some four separate streams of water must pass in and out of the centre post of the crane, whilst at the same time it must be free to revolve in any direction.

This is effected by the arrangement of pipes and glands shown

herewith, where the centre pipe is fixed and passes through the hollow centre of the crane.

This centre pipe is divided into four sections having outlets at different elevations, and over each of these outlets a sleeve is fitted, packed top and bottom, but free to revolve, and to this sleeve a pipe is attached which passes down to the nest of valves in front of the operator. By a new method of effecting the turning, however, only two pipes are required to enter the crane, one inlet and one outlet, all the other pipes being fed by or exhausting into these two pipes.

The lifting-ram of the crane is made to work into two cylinders as shown, the one cylinder being in constant communication with the pressure system, and so acting as a balance to take up just as much of the dead load as is thought desirable, the other cylinder effecting the raising and the lowering of the tables, the water passing into this cylinder practically representing all the water consumed as far as vertical adjustment is concerned.

It is also proposed to drive the rollers by means of a small hydraulic engine, so that the whole of the movements of raising and lowering, rotating, adjusting by means of manipulators, and passing to and fro through the rolls, are effected by hydraulic power.

I may add, in conclusion, that the hydraulic ingot extractor is being put in at the new plant of the Pennsylvania Steel Company at Sparrow's Point, Md., where the whole system of casting and re-heating has been arranged to suit this special method of stripping and handling, whilst the transfer tables will probably be put in for the Central Iron Company, of Harrisburg, in the early spring.

Discussion.

P. Barnes: It may seem somewhat discourteous to enter a general demurrer at this time against this class of machinery, but I venture to do so, as my experience has forced me to study the most rigorous simplicity in all such fixtures, and, indeed, I question seriously whether there can be any useful outcome of apparatus of this sort. It may not be expedient to enter into minute details, but I have an impression that the exposure to

heavy blows, certain to be encountered in the use of such a table, and the need that exact adjustment should be maintained, would be fatal to its ultimate commercial success.

W. L. SCAIFE: Do you refer to the table or the ingot extractor?

P. BARNES: I refer to both of them. So far as my own opinion goes, they are open to great criticism. I should not favor them at all.

MR. WINN: How are the rollers driven?

MR. HYDE: They are driven by a small hydraulic engine.

MR. WINN: Are the rolls three-high?

MR. HYDE: It is a three-high mill. Of course (turning to Mr. Barnes), the table, when swung round, presses against the stop in the housing, and is held against this stop by the full force of the rotating cylinder, and slides up and down, always in contact with the stop. The effect of the hammering is only to be determined by experience.

P. BARNES: If some further remark may be permitted, I may say that during the last four years I have had some oversight of a reversing blooming mill for rolling steel billets. Upon the basis of the experience thus acquired, a new mill has been built and put in operation at the works with which I am connected, and in the design of this mill it was made nearly the chief study to eliminate absolutely the complication of lesser details, which seem to find so important a place in the mechanism now under discussion.

W. L. SCAIFE: In eliminating these troublesome details have you increased or decreased the cost of the work?

P. BARNES: Decreased it by a long margin.

W. L. SCAIFE: In the wages question?

P. BARNES: Yes, in a very important proportion. The type of machinery I referred to is wholly different from this, in the handling and in the manipulating. And yet it may be fair to say that there is a field for mechanism of this kind, and some parts of that field have been usefully and successfully occupied, largely by the gentlemen whose names have occurred to us in this connection, to their great credit, and I have no doubt to their entire satisfaction. What I have seen of these forms has interested me

greatly, but I think in the present case the idea has been carried too far. There is a limit to refinement even in this direction, and I doubt its expediency very much.

I. WINN: I agree with Mr. Barnes in this respect. I have seen instances of this kind in rolling mills. In the hands of the ordinary roller they do not amount to anything. No doubt Mr. Aiken could operate these tables successfully, but very few rollers could do it.

W. L. SCAIFE: There are fewer men employed about these machines.

I. WINN: There may be fewer men employed at the rolls but there are more employed outside in maintaining the machinery. When you have a great deal of complicated machinery it requires a great many more men to maintain it than when the machinery is simple.

From what I have seen of this machinery I believe it would, in the hands of a competent person, be successful; some person that has judgment and mechanical ability. That is the kind of men that will be required for such mechanisms.

T. P. ROBERTS: While I can say that I was interested in the paper, I confess to not fully understanding all its details. This, however, is only natural, as the machine is novel and somewhat complicated, but such a difficulty can be overcome by reference to the diagrams, should they be printed with the paper. We have been accustomed of late to hear much concerning the possibilities of forces and mechanical movements, already devised, and yet to be generated, from electricity, but I am tempted to believe that the possibilities of hydraulic mechanism are as great, if not greater, than exist in any other field presenting itself to the genius of the engineer. The equalized pressures, reliable action, economy, and avoidance of the many ills and dangers attending the use of fire, kes hydraulics very inviting, and when we have mastered, or ast are able to control within fixed limits, the reactions of r, it will no doubt supersede steam in many instances. We at least hope, therefore, to yet see its only needed quality, expansiveness compensated for by an expenditure of a por- f its force acting in reserve. I am glad to know that so

much careful thought has been expended in this direction on a machine specially designed for operating some of the heavy appliances connected with our great iron and steel works, and trust it may prove to be all that its skilful designer claims for it.

Mr. Hyde's paper was discussed by Phineas Barnes, Isaac Wynn, President Scaife and others.

As pointed out in conversation with members interested, Mr. Hyde wished to add that, although the description and sketches may give the impression that these appliances are complicated in construction, difficult to work, and costly to maintain, they are, in reality, much simpler in construction and operation than some other hydraulic appliances in use at Homestead and elsewhere, against which every objection raised to these tables and ingot extractors was raised, when the Homestead appliances were first introduced, but the objections were proved to be as groundless in this latter case, as they will doubtless prove to be as regards the former.

Of course men of intelligence and mechanical skill will be required to operate them, and, fortunately, such men are plentiful.

Whether the average roller possesses the necessary skill or not, is beside the question, as no roller has anything to do with the manipulation of feed tables; this is the province of a mechanic, and an intelligent man will handle them perfectly after twelve hours' practice.

THEORY ON THE ORIGIN OF CLEAVAGE PLANES IN SANDSTONE.

BY THOMAS P. ROBERTS.

(Read at the meeting of the Engineers' Society, W. Pa., Nov. 18, 1890.)

THAT there is a great diversity in the texture, grain and cleavage lines of the sandstones used for building in this vicinity there is no doubt. The stone from some quarries may have an apparently uniform texture, color, etc., and yet be very difficult to split in more than one direction, while other stone of similar texture and composition may split well in two, or sometimes even in three directions, and such differences of qualities are sometimes found

within short limits of distance in the same stratum and quarry. Thus a given block may be easily split open on planes parallel with the "quarry bed," and be very refractory and uncertain on vertical lines crosswise, or lengthwise, so to speak, of the given strata. Such rocks as the last referred to, naturally produce more waste and require much more care and labor upon them not only at the quarries, but at the places where they are finally utilized in buildings. Our blue sands are chiefly of this class, though of late years a greater proportion of better stone is coming into use, even for work below the ground line, from the quarries along the Beaver river valley and other places. It is my observation, although it may not be correct, generically speaking, that this obstinate, cross, or curled grained is not so well adapted to withstand the action of frost as is most of the stone which possesses the merit of splitting well. In some instances, and I think it will be found as a rule for some localities which may hold good, that the refractory areas in otherwise good working veins of sandstone are impregnated with an extra proportion of earthy particles, and therefore not so well calculated to withstand the action of frost, at least this would be a fair deduction from the theory I propose very briefly to develop. It seems strange that some of the coarse open-grained sandstones of this region should withstand the action of frost better than others which are denser, heavier and harder to work when first exposed. We are apt to gauge the durability of stones so far as their ability to withstand frost is concerned by their absorbent qualities, though it may be that the open-grained stone, while very absorbent of water, may drain out and part with its moisture more freely as compared with the dense stones which have clay in their interstices, and which, when once soaked, must retain moisture longer. Coarse particles are apt also to present space for the inevitable expansion which ensues when solid freezing does occur.

The origin of cleavage planes in sandstones presents itself to my mind as an interesting speculation. If the correct theory is developed, and regarding this it does not appear to be involved with very abstract or abstruse considerations, it would be of considerable service to engineers and contractors in many ways, and I

think that in selecting stone heretofore for their constructions our engineers have not paid this subject the attention it deserves.

Primarily the theory of cleavage in stones was left to the lapidarists to solve, but I don't know that they have done more than to become experts in working them to the best advantage, and on materials that the engineer will probably never use extensively. In the building stones proper our masons are very frequently experts, but the mason in one district has to learn his trade over again if he moves out of it.

In discussing the question of the cleavage planes of the sedimentary rocks there has been a vast fund of information thrown open by the geologists, but as to whether this particular topic has been made the subject of special study with reference to the rocks of this part of the American continent I do not know.

The geologist tells us to begin with, and to end with, so far as the history of these great formations is concerned, that the earth's surface or crust frequently rose above and fell beneath the sea level. In other words, it is the generally recognized theory that all our stratified rocks were formed by the agency of water. I speak now of continental formations, for it is scarcely conceivable that the three miles thickness of stratified rocks over which Pittsburg is located for instance, could have been the result of deposits such as are now forming at the mouths of some of the great silt bearing rivers, although these latter may be very extensive so far as area is concerned. But while there are many plausible speculations as to the origin of the comminuted materials which made these rocks there is no longer any doubt that currents of water very broad, and of varying depths and velocities, were the prime factors in transporting them to their final resting place. The bottom velocities, and as I maintain, the direction of these currents, can now be determined to a certain extent by the texture and the grain of the stone. Thus it would appear reasonable to think that coarse conglomerates marked the positions of rapids, and for the extreme in the opposite direction, the slate beds, those areas where a feeble current at last came to rest and dropped its load.

The fundamental principle which governed Captain Eads in

devising his jetties at the mouth of the Mississippi, was laid down in the proposition that a specific velocity enables a current to transport a specific load, and that if that velocity be diminished or increased, as the case may be, it will drop a portion or pick up more load in proportion as its velocity is varied. The order of dropping a load is that heavy particles go first, and hence the assortment of materials with the series terminating in clear, calm water. Alternating currents, such as tides, or those produced by oscillations of the bed tending to disturb water levels, would appear to account for sand rocks in which clay is intimately mixed; or the same may be accounted for by intermittent changes of the velocity alone, for which intermitting changes many causes might be assigned. It is perhaps most reasonable to conclude that the individual strata of our sedimentary rocks were, for the most part, formed by currents flowing in one direction, though their intensity may have varied. In speaking, however, of currents in one direction, reference is here made to prevailing directions which, however, were subject to local disturbances and variations, for we find often in limited areas, sometimes within a few acres, rocks of the same genera, but varying greatly in thickness, texture and grain, which would indicate that there were projections on the older formation which resulted in eddies and swivels, which interfered with the even distribution and depth ot the deposits.

Several years ago, in making a trip over the Monongahela river, in company with several army engineers, one gentleman casually remarked to me that as the current was practically imperceptible, the river being low at the time, in the wide deep pools of the dams, and the boat rounding to make landings, he was occasionally at a loss to say which was up and which was down the river; unless, indeed, he kept a constant watch from the guards. I told him I had been frequently non-plussed myself in that way in coming out of the cabin when the boat was at some unfamiliar landing place, unable to say at first glance which was up or which was down stream, but that I had learned by the appearance of the drift—such as logs, or trees, even twigs—and other objects which usually litter the banks, that they arranged themselves almost invariably with their larger, heavier and "dragging" ends up,

and their lighter, and more slender ends down stream. Exceptions were to be noted where eddies, caused by shore projections interfered with this arrangement. It must be true, then, that every particle of material in suspension in water when free to act will move along with its long axis parallel with the trends of the current. These particles, when not actually touching the bottom, must float with their heaviest end down stream, but the moment they catch the bottom they are rolled over or turned around, coming to rest with their light or tapering end down the stream. The shores of the Monongahela river are entirely of alluvial formation. That is to say the bottom lands are made up of deposits as the river gradually shifted from the base of the hills on one side to the other, and I assume that all these thousands of acres of rich sandy and clay loams, forming a stratum from 20 to 40 feet thick, were formed of material brought down by the river from its various headwaters, and that the particles composing this vast formation were arranged or assorted with their "points" down stream. If this theory be correct we should expect to find this material if it could now be transformed into solid rock, with a grain uniform in direction. I would liken the grain of stone where it is regular to the bristles on an animals back—feeling smoother in one direction than another.

After this material has been partially solidified in the river bank, or become, at all events, tolerably compact, it appears to be able to resist afterwards currents in the downward direction better than it will upward currents. At least I have always observed that eddies caused by even very slight artificial projections from these alluvial banks tend to produce scours in the banks below them.. Near such projections there may be reactions of the water violent enough to account for this scouring action, but where, as in one case I know, the eddy is fully a half mile long, the cutting caving bank extends its whole length, while the upward current near the lower end is not nearly so great as the outside down current. I have thought that the sand "bristles" in the bank by being rubbed against the grain, presented a point for leverage sufficient for the current to overturn them and thus bring them

into suspension once again, something which the same current in the opposite direction could scarcely have done.

In the neutral centre of these eddies, after they have cut considerably into the banks, there is a tendency for circular or elliptical bars to appear, and these at low water will reveal to a careful inspection their materials in annular forms of varying degrees of fineness, the finer particles aggregated in the centre,—a cross-grained obstinate rock in embryo.

Not only can we infer that the water arranges particles of sand favorably disposed in one direction, but that these are deposited in more or less parallel layers, making what we might term horizontal cleavage planes, but that the particles when, as they are of nearly tolerably uniform size, fit together in a systematic arrangement, or a regular *alternating arrangement*, permitting of fracture on vertical lines, thus giving the remaining two possible cleavage planes. This idea could be illustrated with diagrams, but it is, perhaps, unnecessary; for it must appear reasonable to assume that, irrespective of the bond imparted to sandstones by silicious or iron compounds, its greatest strength to resist rupture would be on horizontal lines; hence, when it *must* split vertically, it will part on the lines of least resistance, and these lines will be minutely zig-zagged, following the ins and outs, or points and butts, of the alternately arranged particles. Where these particles are not alternately or systematically arranged, the desired vertical fractures are apt to lead astray and eventually spall off on curved lines, away from the largest mass and towards the point of least total resistance.

Some slate rocks present their only cleavage plane on lines vertical to their natural stratification. I would presume in this case that their materials were deposited in absolutely calm water, that is, that the stream charged with their material, having been perhaps suddenly arrested, proceeds to drop its load. In going straight down the particles strike the bottom and remain standing, with their "butts" or heavy ends down, which would afford only one kind of fitting together, viz., on vertical lines, but there could be no alternate arrangement, on this hypothesis, on horizontal lines. The cleavage plane would then follow on vertical lines

only, though why these planes should produce parallel leaves only is not so clear.

The fact, however, that we seldom, if ever, find vertical cleavage alone in those rocks where a *current* must be supposed to have deposited its particles gives strength to the idea I have sought to develop, viz., that it is only through the agency of currents that the further uniform and alternating arrangement of the sand particles in stone is possible, and which must exist before they can have the property of cleavage in more than one direction.

Discussion.

T. P. Roberts: I will mention for the benefit of some of the members, in reply to Mr. Winn's question, that the Monongahela river is to-day considerably wider than before the days of steamboating. I have some maps showing the river in 1833 and in 1838, and I have also seen maps of the Allegheny river made in 1828, and am therefore certain that such are the facts. There is a great deal in the subject of importance to the City of Pittsburgh, and it is now undergoing investigation on the part of the Chamber of Commerce.

Attention has been directed to the question as to what limitations we should make in regard to encroachments on the river bank, but I shall not undertake to discuss the subject to-night.

A Member: In what direction is the cleavage plane?

T. P. Roberts: I expected to illustrate my ideas on the blackboard, but finding it in use when I came was prevented from so doing. (Mr. Roberts then went to the blackboard and drew a sketch showing the grains of sand in their position in the sandstone, and explaining his ideas of the cleavage planes.)

He then spoke of the difference between sandstone in this connection and the flints of which arrow-heads are made, claiming as his idea that the Indians never made their own arrow-heads, but used those manufactured many years before their time by the Mound Builders who had the art of cutting the stones, an art so delicate that but few lapidarists could duplicate their works in flint, agate and obsidian. There are, therefore, no bogus flint arrow-heads in the market.

A short discussion followed participated in by W. G. Wilkins, P. Barnes, Isaac Winn and others. There being no further business the Society at 10 P. M. adjourned.

THOMAS P. ROBERTS,
Acting Secretary.

DECEMBER 16TH, 1890.

THE Society was called to order by President Scaife at 8.10 P.M. Directors Becker and Wilkins and in all 41 members present.

In the absence of the Secretary, T. P. Roberts was elected to to act as Secretary.

The President read a letter from Secretary Wickersham, who, on account of continued ill health, felt compelled to resign the Secretaryship. President Scaife thereupon communicated to the Society the action of the Board in the premises, by the passing of the following resolution:

Be it Resolved, That the Board of Directors accept with regret the resignation of Mr. S. M. Wickersham as Secretary of the Society, to take effect on the installation of his successor.

And be it further Resolved, That the thanks of the Board be tendered Mr. Wickersham for his faithful and valuable services to the Society during the past five years.

A. Dempster presented the following resolution, which was unanimously adopted by the Society:

Resolved, That the action of the Board, relative to the resignation of Col. S. M. Wickersham, be taken as the expression of the Society; that we tenderly express our sympathy for him in his failing health, and indulge the hope that he may speedily recover and enjoy many days of happiness with his affectionate and loving family.

The President then read a letter from Capt. A. E. Hunt, enclosing some correspondence with Mr. John W. Weston, of the Western Society of Engineers, Chicago, relative to the headquarters of the engineering profession at the World's Fair, to be held

in Chicago, 1893. The following resolution was then presented, and adopted by the Society:

Resolved, That the Engineers' Society of Western Pennsylvania approve of the plan proposed by the Chicago Convention on Joint Headquarters and Engineering Congress for 1893, excepting in so far as it relates to financial assessments.

And Resolved, That this Society respectfully recommends the adoption of a method for raising money, by which all subscribing members in any contributing Society, and they only, be furnished by their Secretary with a card admitting them to the headquarters and accompanying privileges.

The election of new members being in order, the following persons, whose applications had been duly received and approved by the Board, were elected members of the Society of Engineers of Western Pennsylvania: W. C. Temple, Wm. L. Abbott, Theo. Tounelé, J. B. McIntyre, Robt. W. Lyon, Chas. M. Hall, Thos. Spencer, Robt. B. Carnahan, Jr.

The report of the Library Committee, to whom had been referred the question of permitting books or papers to be removed from the library, was presented by Prof. F. C. Phillips, Chairman. The report dwelt upon the difficulties in the way, and upon the liability of loss and damage to books which could not be replaced, should permission be granted members to remove them from the Society rooms. Mr. Metcalf called the attention of the Society to the fact that the gift of $1000, by the late Mr. Wm. Thaw, for the purchase of books, was with the tacit understanding that the Society's library was to be solely a reference library, and such had been the rule since the organization of the Society. On motion, the report of the Library Committee in regard to the matter was approved.

The Committee on Roads reported: "The preamble of the report, and the law proposed for legislative enactment by the Committee, was read at length."

In submitting the report of the Committee on Roads, Thos. P. Roberts said: "I can state that the Committee has had a number of meetings, and has gone over this matter thoroughly. They collected all the proposed acts of other bodies, the work of the

State Commission, the work that has been instituted by the University of Pennsylvania, particularly Professor Haupt. Our Philadelphia friends, however, seem to be off on scientific matters of road building, rather than preparing practical laws."

ANTES SNYDER: I understand from the Chairman of the Committee that they had formulated certain reasons, in which they had set forth in detail why they had presented this law, and I think it would be well for us to hear from them as to what they have to say before we have any general discussion.

T. P. ROBERTS: I omitted a great deal of the preceding portion of the paper that has been already published. It has been modified slightly, but the purpose was to ask the Society to approve this act so that we could have it printed immediately, and have copies enough to send to the members of the Legislature and to the members of the State Road Commission, and to other bodies that are working on this general object of improving roads. We think we have in that law a better general act regarding all the necessities of the case than any we have seen. We would like to hear any suggestions, but the Committee is very anxious to have the matter finally disposed of to-night, but of course if the Society does not wish to take any further action in the matter, it can be held over. There is a great deal to be said on the general merits of the question.

ANTES SNYDER: It is not the general merits of the question that is now before the Society. It is the general merits of this act. Can the members of this Society from merely hearing that act read over once discuss it intelligently?

T. P. ROBERTS: I will state that nine-tenths of that act was once before approved by this Society. The modifications are in type-writer print, while the main portion is in detail, for instance, in connection with the use of roads by pipe-lines. We have supplied little omissions of that kind in making the law more effective, but otherwise it is substantially the same law as was presented a year ago, and which was approved and ordered to be printed by the Society at that time.

ANTES SNYDER: The original law may have been harmonious in all its parts, but every modification, every addition made, would

affect something else in the law, and it may not be the same thing. I noticed one point. The highway fund is to be expended by the commissioners in the improvement and repair of highways. Now where is the money to come from to open new highways. There will be new highways to open. I think there are a good many little points like that that no man can see through—that we cannot comprehend, but need to study for some length of time. They do not occur to you at once, these little inconsistencies. What we want is to get a perfect law. I do not want this Society to send a crude thing down to Harrisburg. It seems to me if this whole matter was printed and furnished to the Society at the next meeting we could discuss it intelligently.

J. F. WILCOX: I noticed in a report of Superintendent Warner, of the workhouse, the use of convicts on the roads, and I had occasion to pass over some of the roads in Georgia that are built by convict labor, and I would like to know what bearing this has on this question. I would like to ask the committee if they considered this matter in the preparation of the report.

T. H. JOHNSON: I would say in reply to that, we have not thought it worth while to make a provision for the use of convict labor. The work done at the workhouse, as I remember the figures, cost in the neighborhood of $4500 per mile, which is about twice the sum a good turnpike ought to cost.

T. P. ROBERTS: We discussed that question of convict labor at several of the meetings, and the unanimous opinion of the members was that it would not be advisable to consider it. The sight of convicts on the county roads would be enough to remind us of the early days when there was tyranny in this and other countries. And the further fact also was dwelt upon that, outside of a few of the larger counties, there are but few prisoners to do the work. The average county has probably ten convicts, of which number not more than two or three are able-bodied men. There are very few really able-bodied men in the prisons. I have seen several papers written on that subject. It is possible the county commissioners could arrange to have the stone broken in the jail-yard. Such things as that could be done under this law.

ANTES SNYDER: There would be nothing to prevent the

superintendent of a workhouse undertaking a contract to build a portion of a road?

T. P. ROBERTS: No, sir.

Further consideration of the report was postponed, and it was ordered to be printed for immediate distribution among the members, and that final action be taken at the next meeting.

H. D. Hibbard then read the following paper:

DEFECTS IN DESIGN OF OPEN-HEARTH STEEL-MELTING FURNACES.

IT is not intended in this paper to cover the whole field of possible or actual defects which may exist in the many parts of an open-hearth furnace. Those here considered have all come under the writer's observation in regular work, and are all he can recall at present.

In some of the cases the means used to counteract the defects will be pointed out. In many the obvious cure is apparent as soon as the true state of affairs is recognized. Some apply only to furnaces fired with artificial, not natural, gas.

They are enumerated below with remarks on each following in order.

They are:

1. Too small gas-ports and ducts.
2. Too small air-ports and ducts.
3. Too large gas-ports.
4. Too large air-ports.
5. Too small regenerators.
6. Too closely-piled checker-work.
7. Too small flues and stack.
8. Working hearth at too low a level.
9. Gas- and air-ports beside each other.
10. Regenerators in which draft is horizontal.
11. Too thin walls and brickwork.
12. Use of clay bricks.
13. Circular hearths.
14. Furnace with ends unlike.

1. *Too Small Gas-ports and Ducts.*—The trouble from this comes, of course, because enough fuel cannot be introduced into the furnace, and the melter complains that the furnace doesn't work well. Stirring up the gas-makers and calling for more gas doesn't help it much. A furnace I have had in charge improved its working qualities after 150 or 200 charges, when the gas-ports and ducts had been enlarged by the fluxing of their sides by the oxide of iron carried over from the working-chamber, allowing freer passage to the gas. A furnace which has been through this experience will, of course, have these passages made larger at the next general repair.

2. *Too Small Air-ports and Ducts.*—This is a serious defect when present, and will not usually correct itself as the furnace grows older in use, as will the preceding, for the reason that the heat is less in the air-ports and ducts. Their lower temperature is because of their greater distance from the working chamber, they being usually nearer the cold outside of the furnace, and, being longer, do not get their share of the outgoing gases from the hearth. All of these that can find room seek the more direct route through the gas regenerator.

This trouble is incurred, as is the preceding, by not taking into consideration the great expansion of the ingoing gas and air, due to the high temperatures they acquire in traversing the hot flues and regenerators. Air increases one volume for every 273° C. it is heated, and, as it doubtless enters the hearth at at least four times that temperature, at least four times as much area of cross-section must be provided for it in the ports near the hearth as it has at the regulating valve where it enters the furnace.

If this case exists, care must be taken to keep the amount of gas in the furnace down to that which the entering air will burn effectively. Any excess of gas beyond this will cool the furnace. If, with this precaution, the results are not good enough the furnace must be altered. Blowing in air as a cure is not advisable, though it might be done if the gas-ports were too large, so that the out-going gases could find vent to the chimney without too strong draft being required. Too strong draft would draw an unusual amount of cold air into the ducts and regenerators, through

the crocks in the brick-work cooling them unnecessarily, thus injuring the working of the furnace.

3. *Too Large Gas-ports, and* (4) *Too Large Air-ports.*—We will consider these together, because, if they exist together in the same furnace, they tend to counteract each other to some extent, but, if only one is too large, trouble arises demanding attention.

The effect of too large ports for either gas or air is that these ingoing fluids, seeking naturally the shortest route, will fill the ducts and ports nearest the front of the furnace, where they enter to their full capacity, so that those on the back side receive little or none. An even distribution of gas and air over the hearth is desired; but, if either has too great passages, it will rise too plentifully at the front, and, flowing into the hearth, give a badly distributed flame, and, of course, bad work. In the portions of the hearth where air is too plentiful, too much waste of stock occurs, and where gas is in excess, a dull smoky flame too cold for good melting is found.

To remedy these defects the ports nearest the front, or the bridge-wall, if one is used for the air to pass over, must be partially closed, which may with many furnaces be done, when running, by loose bricks placed in by means of hooks. The bridge-wall is easily built up from a hole opened in the end-wall of the furnace, and bricks can be added on the front side until a regular distribution of air obtains.

Another way of guarding against the effect of too large air-ports in a furnace using producer-gas is to have the gas-ports brought nearer the front side of the hearth. This will also counteract the effect of any air drawing in around the doors, which too strong chimney draft would cause. The excess of air in front is met with the excess of air, and, if the latter is not too great, fair distribution of the flame results.

A furnace cannot be affirmed to have too large gas- or air-ports until it is up to full melting heat. When first started, and the entering gas and air are quite cold, the front port or ports may seem to be doing all the work, but when these inflowing gases are hot, and, therefore, of much greater bulk, all the ports may be used

to their full capacity. An excess of capacity in the ducts does no appreciable harm if the ports are of the right size.

5. *Too Small Regenerators.*—These cause waste of fuel, because of the heat lost in the outgoing gases due to the high temperature at which they escape into the chimney-flue. All heat which passes the reversing-valves is lost. The valves themselves suffer from the high temperature to which they are thereby exposed, and often require repairs or renewal from this cause. With ample regenerators they may still be damaged by the use, or rather misuse, of too much gas in the furnace, which prolongs the flame down into the regenerators, and even to the valves. I have seen them red-hot from this cause, which, of course, is not the fault of the designer, but the larger the regenerators the less likelihood of such trouble.

Too large regenerators will hardly be put in. I never heard of any trouble laid to that cause, nor can I think of any reason to expect trouble from using any large size which would seem in the least reasonable. By making them large they are less damaged by heat, give longer runs to the furnace and economize fuel.

6. *Too Closely Piled Checker-Work or Regenerator Bricks.*—This often comes from an attempt to correct the defect of too small regenerators. The result is naturally the partial stoppage of the gases passing through either at once when the furnace is new, though it is seldom as bad as that, or after running a greater or less time proportional to the degree of the defect. While the furnace is operated the spaces in the checker-work of the regenerators are gradually filled with oxide of iron in the form of dust, which is carried over by the draft, some being deposited in the regenerators and flues and some issuing at the top of the chimney at times as a light-brown smoke. In the hottest parts of the regenerators this oxide of iron fluxes the bricks, the molten material formed runs down and chills in the lower and cooler parts, and so hastens the stoppage of the passages for the gases. When these passages are not large enough at first, due to the defect we are considering, a short run only can be made before a shut down is forced.

7. *Too Small Flues and Stack.*—This defect requires, of course,

but little consideration here, as after it is recognized the cure is obvious.

The flues between the regenerators and reversing valves and the chimney flue collect some of the oxide of iron brought over from the hearth, the deposit being heavier the nearer the furnace. This deposit will in time grow large enough to interfere with the working of the furnace by restricting the flue area, unless there has been ample excess provided for it in the furnace design.

The stack, if large enough at first, will remain so, as it is not liable to stoppage.

It should be borne in mind, that as the drawing power of a stack depends on the temperature of the gases within, that one which is ample with small regenerators and consequently hotter escaping gases may be not high enough with larger regenerators, which cool the gases much more before they reach the stack. More height, but not more area of cross-section is needed in the latter case. In fact, less sectional area would serve, as the volume of escaping gases, due to their lower temperature, is less than in the former case.

8. *Working Hearth at Too Low a Level.*—This is with reference to the point of entrance of the air and not the ground or working floor, though it usually will be to the ground also, as the air nearly always enters at about its level.

The point is as follows: A regenerative furnace, to work well and be under complete control, must have both gas and air introduced to the working chamber under pressure, the chimney being used only to take away the waste gases as fast as formed. Bad work, and especially heavy waste of iron will result, if the chimney draft is used to draw air or gas into the furnace. When it is used at all to assist in this way, it will also draw cold air in through the cracks around the doors and in the brickwork, which will injure the heat of the furnace.

Gas from producers is forced in by the pressure of the steam-blast under the fires; natural gas, by the pressure from the wells. Therefore the gas needs not this precaution, but with the air the case is different. In a furnace with a high-working hearth, having in consequence high regenerators and a very considerable

difference in level between the air-valve and hearth, there is a column of air of that height, strongly heated and rarefied, which causes it to rise and flow into the working chamber unaided.

When, from any construction, this column of heated air is too low, so that an outward pressure or plenum cannot be maintained in the working chamber, together with a suitable flame, air should be blown in preferably by a fan-blower. Indeed, the working of many, if not all furnaces, would be improved by being supplied with air under greater pressure than it usually has.

9. *Gas- and Air- Ports Beside Each Other, or Arranged so as Not to Bring the Air Into the Working Chamber Above the Gas.*—The air should enter above, because this keeps the flame down on the charge, which is thereby melted faster and away from the roof, which is then not melted so fast, two desirable conditions to maintain.

The incoming air, though heated, is still colder than the other gases in the working-chamber, and therefore tends to flow down along the bottom of the chamber, as does cold air entering a warm room. If there is no gas below to intercept and burn it, undue oxidizing conditions will exist around the charge, and too much waste and its consequent trouble ensue. The chief reason though for introducing the air above the gas has been the preservation of the roof, though this is becoming less urgent as higher roofs become common. Better combustion also results from the intimate mixture of the gas and air caused by the latter falling into and through the flame from above.

10. *Horizontal Regenerators.*—By this is meant those in which the gases flow horizontally instead of vertically or diagonally, as is usual.

In horizontal regenerators, the outgoing gases, being hotter than the chamber, naturally flow out along the upper levels, while the ingoing, being colder, flow in along the lower levels. As a consequence, much of the efficiency of the regenerators is lost. The top keeps hot and the bottom cold, comparatively speaking. The waste gases reach the chimney hotter and the ingoing reach the hearth colder than the size of the regenerators ought to permit.

If the regenerators are built as flues and their cross-sections are

so small that the whole area is needed to convey the moving gases, this evil is avoided; but another one is met, namely: that as soon as the effective area is reduced by the deposition in the regenerators of dust carried from the hearth, they will be too small for their purpose.

Enlarging the regenerators will not greatly increase their effectiveness, if they are shown to be inadequate, by the high fuel consumption and high temperature of the waste gases, as long as the principle of the horizontal draft is adhered to.

11. *Too Thin Walls and Brickwork.*—It is a question just how thick these should be, but in general they should be so thick that working about the furnace is reasonably comfortable as regards heat, even in summer. This is especially applicable to the doors, which are sometimes bricked up only 2½ inches thick, making it warm for the workmen.

As with high roofs and increased skill in judging the temperature of the hearth by the melter, the life of the furnace, and especially of the roof, is being prolonged, the writer thinks the time has come for increasing the thickness of the roof over the regulation 9 inches. More bricks, or, perhaps better, an equivalent thickness of sand, which will rise and fall with the roof, would save much of the large amount of heat now lost by conduction through the roof with an equivalent saving of fuel.

12. *The Use of Clay Bricks* is, in the light of current practice, to be considered a defect. Campaigns of a thousand heats or over being at least occasional, and of five hundred quite common, clay bricks giving a hundred are dear at any price, or even no price.

13. *Circular Hearths.*—The evident faith of designers of these hearths was that the flame would spread itself out as it entered the hearth, so as to insure an even heating in all parts. Instead of this, however, we find the flame taking its straight path through the chamber, melting a swath through the charge at first, the stock out of its course melting with heavy waste afterward. Probably no more of these will ever be built, at least until those who have used them have left the steel business.

14. *Furnace with Ends Unlike.*—This is, of course, very unusual, due to the local situation in the shop, only one case being

known to the writer. The regenerator at one end of a furnace was cut off to make room for another furnace, the equivalent regenerative capacity being secured in another way. The chief trouble came from the difference in draught in the two ends. As a consequence, seven different motions were required to reverse the furnace, viz.: (1) shut off gas; (2 and 3) throw the two reversing-levers; (4) turn on gas at the other end; (5 and 6) adjust two air-valves; (7) adjust chimney damper. Natural gas was used. Still the furnace was made to work after a fashion, though at the first opportunity it was restored to its original form, as the room seemed to be used more profitably that way.

To conclude, a furnace may have several of these defects, which perhaps, will only be recognized successively. As one is remedied it brings into prominence another which, being righted, may develop a third, and so on. Much time and money are usually wasted before a furnace defectively designed is brought into proper shape and has suitable proportions all through for good work. Frequently entire rebuilding would be the cheapest cure in the end.

Some furnaces may work well for short runs, and only show the effect of bad design when, due to increased skill of the melters, long campaigns become possible were the furnace rightly built. The proof of a furnace is, of course, its record in the hands of competent men, and one which has melted five hundred heats at a fair rate and with good economy of fuel ought to be altered with extreme caution, if at all.

Discussion.

Wm. Metcalf: I noticed one or two points in the paper which were especially interesting to me. I listened a long time for the author to mention the flues. He finally did mention inadequate flues. I found a good many years ago that the Siemens furnaces, as designed or built according to the designs furnished by the patentees or the agents in this country, never worked quite satisfactorily. I do not speak now of the open hearth, because I do not use them, but crucible furnaces. The difficulty was aggravated there. It was very difficult to get a good flame in the farther

end of the furnace. After a great deal of study and bothering with the furnaces, I came to the conclusion that the whole trouble was with the flues below the checker-work, and in designing the furnace, which is probably the largest furnace of this kind in the world, I think certainly is, a sixty-pot crucible furnace, fifty feet long, the farthest melting hole is fifty feet from the valves. The question of getting a furnace of that length sufficiently hot at the farther end, was a serious difficulty. After a careful study, I designed each flue one and a half times the size of the total area of all of the ports. The gas flues were perhaps one and a half times the size, and the air flues twice the size, making the flue under the checker work, fifty-four inches deep. That is the best furnace we have ever had and the most economical, and the melting hole fifty feet from the valve is as hot as the nearest hole to the valve. I think that insufficient flues under the checker work in many designs I have seen in open-hearth furnaces, is one of the most serious causes of imperfect work of any of the defects mentioned, for the reason that the gases will then take the most direct course, fill up the front ports, and you never get the back ports hot, whereas, if there are large valves and plenty of room in the flues for the gas to flow in, it will fill all of the ports, and you have your furnace nicely and evenly heated.

The only remark in the paper that I would criticize is that in reference to the roofs. I think if the author tries it, he will find that probably the standard nine-inch roof is a happy accidental medium. I have tried when they became a little defective to patch roofs up by putting a cover on, and in every case it was a certain failure. Where a little sand or fire-clay has been left on the roof by the bricklayers, the roof will get red-hot at that point up to the sand, and in a short time the roof will give way and come down, so that now whenever we put a roof in our furnaces, I am always careful to have them swept clean. I think that would be the effect of sand on the roof. I doubt very much whether a thirteen inch brick wall would do at all, unless the bricks were made whole, thirteen inches, because $4\frac{1}{2}$ inches over the 9 inch cover would let the lower arch get red-hot, and the bricks would be destroyed very rapidly and come down. On

the other hand, if they were made 13 inches long they would be very cold on top. My impression is that a change in temperature would cause the bricks to drop out in lumps, and crack as they do now frequently in the 9-inch roofs. And further, when the crown of the arch was burnt thin, the arch at the sides would be so much heavier that they would break the roof in.

I have not had much experience with open hearth furnaces for melting steel, but have had for melting iron, and that is about the way they act.

J. W. LANGLEY: In speaking of some of the defects of furnaces, I notice that the writer said nothing about the possible defect of too large size. I would like to ask if he has arrived at any conclusion as to what is the maximum size to which an open hearth furnace can be built and run successfully.

H. D. HIBBARD: I do not know that that point ought to be included under this head. I think that question is one entirely to be governed by the size of ingots it is desired to make. If you want 50-ton ingots, make 50-ton furnaces; if you want 100-ton ingots, make an equal size furnace. The size is based on the size of ingots required, the furnace being to some extent in proportion to the size of ingots to be cast. I think it would be practicable to build 50-ton furnaces and cast 100-ton ingots. By any system of casting I know of, it can be done successfully if the steel be at the proper temperature at the beginning, the furnace being in proportion. Otherwise, it would be too cool at the end, and if the ingot had the proper temperature at the end, then the cast at first would be too hot, and we all know what that means, the steel would be of inferior quality. My answer to the question would be that the furnace should be definitely proportional to the size of ingots desired.

J. W. LANGLEY: You think a 100-ton furnace could be built?

H. D. HIBBARD: Yes, sir; I do. I say entirely practicable. There is one difficulty with very large furnaces which comes in, and that is that the men who work them are no larger than those who work the smaller furnaces, and the tools necessarily become so large and so heavy that it is rather troublesome to keep the

bottom in good shape and repair, while all the other work around the furnace is increased also, but I believe even then it is possible with machinery of some kind devised for performing the operations which are difficult. With the proper machinery we could charge 100-ton furnaces as well as smaller sizes.

T. P. Roberts: Would there be any economy in the large furnaces?

H. D. Hibbard: I think that is a question, too, depending on what you call economy. If you want large quantities of large ingots there is economy in large furnaces in every way, economy in labor. I think there would be some economy in fuel the larger the furnace, provided it were properly proportioned.

W. Metcalf: I stated a few moments ago that the large crucible furnace I built was the best and most economical one we have. I will say that that furnace will melt crucible steel with 25 per cent. less fuel than any furnace we have, and I have never seen a furnace too big. The larger you get them the more economical they are. There is a limit, I suppose, but I have never seen a furnace which would not be improved by making it larger.

I would like to show the evolution of the old reverberatory furnace. (Mr. Metcalf here illustrated on the blackboard the old type of furnace, and also described the improvements made in the same.)

This (No. 1) is the first style of furnace I have any knowledge of. It has a pitched roof, and by some ingenious means they had the tap hole the farthest away from the fire. I presume it took about twenty bushels of good coal to melt a ton of iron. The first change made was the moving of the tap hole nearer the bridge-wall, so that the pool of melted iron would be nearest the heat. The next, in order to get a larger heat, was to straighten up the crown, and then, in order to get still larger heats, the crown was straightened up in this way (illustrating), and the kitchen was made larger above the bridge-wall. This form, lastly, occurred. At the Fort Pitt Foundry, during the war, one furnace had to be repaired. It interfered with a passage-way, and to get out of that trouble we cut the stack off and put it on the side. We were told there would be a cold corner at the back end. We tried it, and, in-

stead of a cold corner, this furnace began to melt the iron at this end as quickly as any other, and much quicker than any furnace we had. Then we built all the largest furnaces in this form, the flame coming out at the side. It became necessary to have a very large capacity, and the question was raised as to whether we could build a furnace that would melt forty tons. This is a direct answer to the question about the size of the furnace. One of the army officers and some of the people around the foundry thought that a large mass of iron could not be melted without ruining it. Our necessities were so great that it was finally decided to build it. The kitchen of that furnace was 7 feet high, 11 feet wide, 17 feet long. These are the clear dimensions. It was just a common coal furnace. It was quite common to charge 40 tons of iron in this furnace. We put a whole gun in sometimes. We would start the furnace cold in the morning, and melt the charge in from 3½ to 4 hours.

One year I took a very accurate account of the fuel used in these different furnaces. I weighed every pound of coal that went to every furnace in the place. The result, as near as I can remember, was as follows: This furnace, which we will call No. 3, took about 16 bushels to a ton of iron. This was a 10-ton furnace. The 15-ton furnace would melt with about 13 bushels. The 25-ton furnace, made in the new shape, would turn out a full melt with 7 to 8 bushels. Remember, these are actual weights taken for the whole year. The furnaces ran every day, excepting when down for repairs. The 40-ton furnace took 4½ to 5½ bushels per ton. That is the advantage of the big furnaces.

A. Snyder: Did you notice any great saving of the loss in melting?

W. Metcalf: We had no opportunity to observe that. We had to get enough in every time. I remember the figures in round numbers. This was about the way the furnaces acted. That furnace had a two feet rise in the crown here, and that had a great deal to do with the saving of fuel. We raised the crown and gave room for combustion. Of course there is a limit, but as far as my experience goes I have never seen a furnace too large.

A. Snyder: How about the relative life?

W. Metcalf: That big furnace would run about as long as the

others. The average life was only about six or eight weeks, because, being coal-furnaces, we had to make new sand-bottoms every day. They were charged cold every morning, and then fired up with all the draft of a tremendous stack. The stack to that big furnace was 11 feet in diameter and 70 feet high. Sometimes the fireman would neglect his fire, and the grate-bars would begin to vibrate under that tremendous draft, making such a noise that several hundred feet away you could not hear the noise of the machinery in the mill; it seemed like a wizard's shop, all life and no noise.

J. HOPKE: I would like to ask Mr. Hibbard's opinion of the style of roof in the so-called circular furnaces. The Lash furnaces use natural gas. The gas goes in a pipe here (illustrating), and then there is a roof swinging directly over this neck. The flame strikes this projection here, and it burns away very quickly.

H. D. HIBBARD: I do not know that I have had experience with that type.

T. M. HOPKE: I know of one furnace in which they got out seven heats, and then the projection was burned away entirely. They had to put an entire new roof on.

W. METCALF: I cannot believe those projections are any use. In a conversation with Dr. Wedding, when here with the foreign engineers, he stated that they run little furnaces in Europe of a bee-hive shape; but after my experience with the big furnace I never had any desire to use a roof going any way but up.

T. M. HOPKE: It may be interesting to some of the members to mention a little conversation I had to-day with a gentleman who tells me that he has an open-hearth furnace—I think a 5-ton furnace—which makes an excellent steel without regenerating at all. He heats his air to the temperature of 6700°, and brings that through a burner. He mixes that thoroughly with the gas, and with that mixture he gets perfect combustion, has a better temperature, and has better control of the furnace, and yet does not regenerate at all. He says that the pipe never gets above a dull-red heat.

H. D. HIBBARD: I think the furnace just mentioned is hardly correctly-styled as not regenerative. The air is heated by the waste heat of the furnace. I would not approve of any system of re-

generation in which the heat is conducted through anything; that is, in comparison with the principle of the Siemens regenerative furnace, which effects its regeneration by the means of reversing, with which we are all familiar.

W. METCALF: Did he give you any data as to the endurance of that furnace?

T. M. HOPKE: The furnace has only been running a short time but he thinks there is no reason why it should not last for a very long run.

T. P. ROBERTS: What is the fan-pressure developed for these furnaces?

H. D. HIBBARD: I never measured it, but it is not great. I presume a pressure of 6 inches of water would be ample. I know of one case where a fan-blower was put in for that purpose coupled to run a thousand revolutions. That would be a pressure of about one-half pound, or about one foot of water in round numbers. That was too big entirely. It was reduced to 400 revolutions, which was even found greater than was required. I presume, therefore, it would be less than six inches—probably from four to six inches.

W. Metcalf, Chairman of the Committee on Nomination of Officers for the ensuing year, reported that the following-named gentlemen had been nominated:

For President, Thomas P. Roberts; for Vice-President, A. E. Hunt; for Secretary, J. H. Harlow; for Treasurer, A. E. Frost; for Directors, two years, G. S. Davidson, Thos. H. Johnson.

At 11.15 P.M., the Society adjourned.

T. P. ROBERTS,
Secretary pro tem.

OFFICERS FOR 1891.

PRESIDENT,

One Year—T. P. Roberts.

VICE-PRESIDENTS,

Two Years—A. E. Hunt. One Year—Phineas Barnes.

DIRECTORS,

One Year—R. N. Clark. One Year—W. G. Wilkins.

Two Years—Geo. S. Davidson. Two Years—Thos. H. Johnson.

SECRETARY,

One Year—James H. Harlow.

TREASURER,

One Year—A. E. Frost.

COMMITTEE ON LIBRARY,

F. C. Phillips, Chairman, L. B. Stillwell, Charles Davis, E. B. Taylor, H. D. Hibbard.

COMMITTEE ON ROOMS,

R. N. Clark, Chairman, G. S. Davidson, E. V. McCandless, Wm. Thaw, Jr.

COMMITTEE ON PROGRAMME,

W. G. Wilkins, Chairman. Emil Swenson, T. M. Hopke, Henry Aiken, H. P. DuPuy, P. Barnes.

LIST OF MEMBERS.

DATE OF MEMBERSHIP.		
Dec. 16, '90.	Abbott, W. S.,	48 Fifth Av., Pittsburg, Pa.
May 21, '80.	Aiken, Henry,	508 Lewis Building, Pittsburg, Pa.
Mar. 20, '88.	Aikman, Edw. G.,	115 Broadway (Room 95), New York.
Oct. 20, '85.	Albree, C. B.,	18 Market St., Allegheny, Pa.
Apr. 20, '80.	Amsler, Chas., M.E.,	Bissel Block, Pittsburg, Pa.
Dec. 16, '84.	Anderson, J. W.,	45 Fremont St., Allegheny, Pa.
Jan. 6, '80.	Armstrong, Edw.,	Supt. Alleg. Water Works, 160 Webster Ave., Allegheny, Pa.
Jan. 6, '80.	Armstrong, H. W.,	Metcalf, Paul & Co., Pittsburg, Pa.
Jan. 18, '87.	Arms, W. F., M.E.,	R. & P. C. & I. Co., Punxsutawney, Pa.
Nov. 20, '88.	Arras, John W.,	P. O. Box 485, Pittsburg, Pa.
Apr. 15, '60.	Ashworth, Daniel,	Hamilton Building, Pittsburg, Pa.
Feb. 21, '82.	Aull, W. F., C.E.,	Manager Denny Estate, Box 91, Pittsburg, Pa.
Jan. 6, '80.	Awl, John L.,	Mgr. Monong. Incline Plane, Pittsburg, Pa.
Sept. 20, '87.	Bailey, Chas.,	Reliance Steel Casting Co., 36th St. and A. V. R. R., Pittsburg, Pa.
Sept. 16, '84.	Bailey, Jas. M.,	Mfr. Sligo Iron Works, Pittsburg, Pa.

Date of Membership.		
Jan. 15, '84.	Baker, Chas. H.,	Metcalf, Paul & Co., Verona, Pa.
May 18, '84.	Bakewell, Thos. W.,	Bakewell Building, Pittsburg, Pa.
June 19, '88.	Bakewell, Wm.,	110 Diamond St., Pittsburg, Pa.
Apr. 17, '88.	Barbour, Geo. H.,	20 Portland Block, Chicago, Ill.
May 19, '85.	Barnes, Phineas,	Jones & Laughlins, Ltd., Pittsburg, Pa.
May 20, '90.	Barret, J. H.,	134 Jackson St., Allegheny, Pa.
Nov. 21, '82.	Bates, Onward,	Rand & McNally Bldg., Chicago, Ill.
Jan. 6, '80.	Becker, Max J.,	C. Eng., P., C. & St. L. Ry., Pittsburg, Pa.
Jan. 20, '85.	Beckfield, Chas.,	804 DuQuesne Way, Pittsburg, Pa.
Nov. 19, '89.	Bell, W. G.,	P. O. Box 976, Pittsburg, Pa.
Dec. 18, '83.	Benney, Jas.,	Emsworth, Pa.
Jan. 6, '80.	Bigelow, E. M.,	Chf. of Dept. of Public Wks., Pittsburg, Pa.
Feb. 19, '89.	Billen, C. E.,	Supt. Bridge & Const. Dept. Penna. Steel Co., Steelton, Pa.
Mar. 18, '91.	Black, S. W.,	99 4th Ave., Pittsburg. Pa.
Sept. 18, '83.	Blank, Hugo,	Chemist, 77 4th Ave., Pittsburg, Pa.
Jan. 11, '89.	Blaxter, G. H.,	Allegheny Co. Light Co., Pittsburg, Pa.
Mar. 18, '84.	Bole, W. A.,	Supt. West'ghouse Mach. Co. 25th and Liberty Sts., Pittsburg, Pa.
Jan. 6, '80.	Borntraeger, H. W.,	Keystone Bridge Co., Pittsburg, Pa.

Date of Membership.		
Apr. 19, '81.	Boyd, Henry A.,	National Tube Works, McKeesport, Pa.
Mar. 18, '84.	Brashear, John A.,	Optician, Observatory Ave., Allegheny, Pa.
Feb. 17, '91.	Braune, J.,	Keystone Bridge Co., Pittsburg, Pa.
Nov. 16, '80.	Bray, Thos. I.,	Warren, O.
Apr. 19, '87.	Breen, H.,	Keystone Bridge Co., Pittsburg, Pa.
Jan. 6, '80.	Brendlinger, P. F.,	79 Warburton Ave., Yonkers, N. Y.
Jan. 19, '86.	Brockett, Alonzo H.,	Mellor & Hoene, Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Browne, Geo. H.,	Supt. Water Works, Pittsburg, Pa.
Jan. 6, '80.	Brown, W. R.,	City Engineer's Office, Pittsburg, Pa.
Apr. 18, '82.	Brunot, H. J.,	Greensburg, Pa.
Jan. 18, '87.	Buente, C. F.,	Stone Contractor, Duquesne Way & 10th St., Pittsburg, Pa.
Jan. 6, '80.	Bullock, W. S.,	Taylor & Bullock, Pittsburg, Pa.
Sept. 21, '80.	Burgher, Rutherford,	Treasurer Kidd Steel Wire Co., Ltd., Harmarville, Pa.
Jan. 19, '86.	Cadman, A. W.,	Brass Manufacturer, Pittsburg, Pa.
Dec. 20, '87.	Campbell, Hugh C.,	187 Sandusky St., Allegheny, Pa.
May 23, '82.	Camp, Jas. M.,	Duquesne, Pa.
Feb. 20, '83.	Carhart, Danl.,	C. E., Prof. Math. and Eng., Western University, Allegheny, Pa.
May 19, '85.	Carlin, Thos. H.,	Machinist, 186 Lacock St., Allegheny, Pa.

Date of Membership.		
Nov. 18, '84.	Carlin, David,	Mgr. W. G. Price & Co. Iron and Lead Works, 5th Ave. and Price St., Pittsburg, Pa.
Dec. 16, '90.	Carnahan, R. B.,	339 Shetland Ave., Pittsburg, Pa. E. E.
Apr. 20, '80.	Carnegie, Andrew,	Steel, 55 Broadway, New York.
Mar. 18, '91.	Caughey, E. G.,	19 North Ave., Allegheny, Pa.
Sept. 18, '83.	Chambers, J. S., Jr.,	C. E., Box 212, Trenton, N.J.
Feb. 17, '80.	Chess, H. B.,	Chess, Cook & Co., Nails and Tacks, Pittsburg, Pa.
Nov. 21, '82.	Clapp, Geo. H.,	Chemist, 95 and 97 Fifth Ave., Pittsburg, Pa.
May 19, '89.	Clark, Louis J.,	Western Pa. Phonograph Co., 146 Fifth Ave., Pittsburg, Pa.
Jan. 18, '88.	Clark, R. N.,	Rustless Iron Co., 32d and Smallman Streets, Pittsburg, Pa.
Oct. 16, '83.	Coffin, Wm.,	Draughtsman, Franklin St., Allegheny, Pa.
Apr. 19, '87.	Colby, J. A.,	Wilmington, Del.
Feb. 22, '81.	Cooper, Chas. H.,	Bakewell Building, Pittsburg, Pa.
Dec. 20, '81.	Cooper, John W.,	Draughtsman, Pitts. Locomotive Works, Allegheny, Pa.
Nov. 19, '89.	Cornelius, W. A.,	Hazlewood, B. & O. R. R., Pittsburg, Pa.
Sept. 21, '80.	Curry, H. M.,	Lucy Furnace Co., Pittsburg, Pa.
May 23, '83.	Danse, L. O.,	Architect, Webster Ave. and Morgan St., Pittsburg, Pa.
June 19, '88.	Davis, Chas. H.,	1026 Pine St., Philadelphia, Pa.

DATE OF MEMBERSHIP.		
Jan. 6, '80.	Davis, Chas.,	County Eng., Court House, Pittsburg, Pa.
Dec. 21, '80.	Davison, Geo. S.,	Westinghouse Building, Pittsburg, Pa.
Feb. 17, '91.	Deforth, John M.,	Keystone Bridge Co., Pittsburg, Pa.
Jan. 6, '80.	Dempster, Alex.,	C. E., Coal Operator, Standard Bldg., Pittsburg, Pa.
Jan. 6, '80.	Diescher, Samuel,	M. E., Hamilton Building, Pittsburg, Pa.
Apr. 19, '81.	Dixon, C. G.,	Contractor, 34 Park Way, Allegheny, Pa.
Nov. 15, '87.	Dobson, Thos. H.,	Penn P. O., Lancaster Co., Pa.
Apr. 15, '84.	Dravo, H. G.,	Iron Mcht., 413 Wood St., Pittsburg, Pa.
Jan. 18, '88.	DuBarry, H. B.,	Office Ch. Eng. Pa. Lines, Pittsburg, Pa.
Jan. 22, '89.	DuPuy, H. P.,	Westinghouse Building, Pittsburg, Pa.
Sept. 16, '90.	Davis, A. R.,	Edgar Thomson St'l W'ks, Braddock, Pa.
Oct. 21, '90.	Dravo, E. T.,	49 Fifth Ave., Pittsburg, Pa.
Nov. 18, '90.	Duxrud, Peter,	Park Bros., Pittsburg, Pa.
Jan. 18, '81.	Eckert, E. W.,	C. E., 34 West 38th St., New York.
Jan. 6, '80.	Edeburn, W. A.,	Eng. and Surveyor, Bakewell Building, Pittsburg, Pa.
Mar. 18, '91.	Edwards, J. P.,	Uniontown, Pa.
Jan. 6, '80.	Ehlers, Chas.,	City Eng., No. 8 City Hall, Allegheny, Pa.
Feb. 27, '88.	Engle, Geo. W.,	Eng. Gen. Office. Penna. Co., Pittsburg, Pa.
Sept. 19, '82.	Engstrom, F.,	Engineer, Penna. Co., Pittsburg, Pa.

Date of Membership.		
Feb. 4, '88.	Estrade, E. D.,	Engineer, Chief Eng. Office, P., C. & St. L. Ry., Pittsburg, Pa.
Nov. 15, '87.	Euwer, A. H.,	Lumber Merchant, Allegheny, Pa.
Mar. 6, '86.	Ferris, Geo. W. G.,	C.E., Insp. of Iron and Steel, P. O. Box 539, Pittsburg, Pa.
Apr. 19, '87.	Fielding, J. S. C. E.,	Peterborough, Ont.
Jan. 20, '85.	Fitler, F. K.,	121 Water St., Pittsburg, Pa.
Apr. 16, '89.	Fleming, H. S.,	1409 Walnut St., Philadelphia, Pa.
Jan. 18, '87.	Follansbee, Gilbert,	Supt. Chamber of Commerce, Pittsburg, Pa.
Oct. 21, '90.	Foster, Jas.,	Care Jennings Bros. & Co., Pittsburg, Pa.
Feb. 21, '82.	Frank, Isaac W.,	Founder, Lewis Foundry Co. Pittsburg, Pa.
Jan. 6, '80.	Frost, A. E.,	Prof. of Physics, W. U., Perryville Ave., Allegheny, Pa.
Apr. 17, '88.	Fulton, Louis B.,	Chancery Lane, Pittsburg, Pa.
Jan. 19, '86.	Geisenheimer, W. A.,	608 Fifth Ave., Pittsburg, Pa.
Apr. 15, '90.	Giles, W. A.,	Schmidt Bldg., Pittsburg, Pa.
Oct. 16, '83.	Glafey, Frederick,	Keystone Bridge Works, Pittsburg, Pa.
Feb. 17, '80.	Goodyear, S. W.,	Waterbury, Conn.
Jan. 21, '90.	Goodwin, J. M.,	Sharpsville, Mercer Co., Pa.
Jan. 6, '80.	Gotleib, A.,	Room 75, Major's Block, Chicago, Ill.
June 16, '85.	Grant, Horace E.,	119 First Ave., Pittsburg, Pa.
Apr. 21, '85.	Griffen, A. L.,	Keystone Bridge Co., Pittsburg, Pa.
Sept. 19, '82.	Gwinner, Fred., Jr.,	Contractor, Allegheny, Pa.

Date of Membership.		
Mar. 20, '83.	Hackett, Geo. W.,	Cement, Lime and Terra Cotta, 1009 Library St., Pittsburg, Pa.
Dec. 16, '90.	Hall, Chas. M.,	95 Fifth Ave., Pittsburg, Pa.
May 17, '80.	Hammer, Hakon,	4605 Fifth Ave., Pittsburg, Pa.
Oct. 15, '89.	Handy, J. O.,	95 Fifth Ave., Pittsburg, Pa.
Feb. 17, '91.	Hardie, J. B.,	Keystone Bridge Co., Pittsburg, Pa.
Jan. 6, '80.	Harlow, Jas. H.,	Hydraulic Engineer, 411 Wood St., Pittsburg, Pa.
Apr. 19, '81.	Harlow, Geo. R.,	Hydraulic Engineer, 441 Wood St., Pittsburg, Pa.
Jan. 6, '80.	Hemphill, Jas.,	Machinist, Mackintosh, Hemphill & Co., Pittsburg, Pa.
Nov. 14, '85.	Heron, Fred.,	Supt. Phœnix Iron Works, Phœnixville, Pa.
Jan. 19, '86.	Hetzel, Jas.,	60 Fourth Ave., Pittsburg, Pa.
Apr. 19, '87.	Hibbard, H. D.,	Care Dr. Litchfield, Neville St., E. E., Pittsburg, Pa.
Feb. 17, '91.	Hicks, Geo. J.,	Room 509, Lewis Bldg., Pittsburg, Pa.
Nov. 20, '88.	Hoag, I. V., Jr.,	43 Sixth Ave., Pittsburg, Pa.
Apr. 20, '80.	Hoffstot, Frank N.,	Iron Broker, Water St., Pittsburg, Pa.
Sept. 18, '88.	Hohl, L. I.,	Ruth St., 32d Ward, Pittsburg, Pa.
Dec. 18, '88.	Holland, W. J.,	Fifth Ave., Oakland, Pittsburg, Pa.
Nov. 15, '87.	Hopke, T. M.,	Linden Steel Co., Pittsburg, Pa.
Oct. 16, '88.	Howe, H. M.,	287 Marlboro St., Boston, Mass.

Date of Membership.		
Oct. 18, '81.	Hunt, A. E.,	Chemist, Schmidt & Friday Bldg., Pittsburg, Pa.
Jan. 22, '89.	Hunt, H. E.,	Emerson St., E. E., Pittsburg, Pa.
Oct. 21, '90.	Hutchinson, G. H.,	Keystone Bridge Co., Pittsburg, Pa.
Oct. 18, '87.	Hyde, C.,	Eng., Room 23, Lewis Bl'k, Pittsburg, Pa.
Mar. 18, '80.	Jarboe, W. S.,	14 Garfield Ave., Allegheny, Pa.
Dec. 18, '88.	Jenkins, J. B.,	98 Arch St., Allegheny, Pa.
Feb. 22, '81.	Jennings, B. F.,	Preble Ave, Allegheny, Pa.
Jan. 18, '88.	Johnson, Thos. H.,	Penna. Lines, Tenth and Penn Sts., Pittsburg, Pa.
Apr. 19, '81.	Jones, B. F.,	Iron Manufacturer, Pittsburg, Pa.
Mar. 20, '88.	Jones, W. Larimer,	Jones & Laughlins, Ltd., Pittsburg, Pa.
Nov. 16, '80.	Kaufman, Gustave,	814 Hamilton Building, Pittsburg, Pa.
May 16, '80.	Kay, J. C.,	Machinery, Kay Bros. & Co. Water St., Pittsburg, Pa.
Feb. 17, '85.	Kay, Jas. I.,	Patent Attorney, 96 Diamond St., Pittsburg, Pa.
June 19, '88.	Keating, A. J.,	Iron Mfr., Zug & Co., Pittsburg, Pa.
May 21, '89.	Keenan, J. J.,	Hollidaysburg, Blair Co., Pa.
Mar. 17, '85.	Kelly, J. A.,	28th and Smallman Sts., Pittsburg, Pa.
Jan. 16, '85.	Kelly, J. W.,	Box 196, New Brighton, Beaver Co., Pa.
Feb. 17, '91.	Kemler, W. H.,	1823 Carson St., Pittsburg, Pa.

Date of Membership.		
May 18, '86.	Kennedy, Julien,	Latrobe, Pa.
Sept. 19, '82.	Kenyon, L. H.,	Pitts. Locomotive Works, Allegheny, Pa.
Mar. 19, '89.	Kerr, A. C.,	Third Ave., Pittsburg, Pa.
Mar. 18, '90.	Kerr, C. V.,	42 Clifton Park, Allegheny, Pa.
June 19, '88.	Kimball, Frank I.,	Mining Engineer, Greensburg, Pa.
Feb. 21, '82.	King, T. M.,	B. & O. R.R., Baltimore, Md.
Mar. 16, '82.	Kirk, Arthur,	Arthur Kirk & Son, Powder and High Explosives, 910 Duquesne Way, Pittsburg, Pa.
Nov. 15, '87.	Kirtland, A. P.,	Acmetonia, Pa.
Apr. 19, '87.	Klages, Geo. W.,	Machinist, Foreman, 130 Eleventh St., S. S., Pittsburg, Pa.
Apr. 19, '87.	Koch, Walter E.,	Supt. Spang's Steel Works, Sharpsburg, Pa.
Jan. 6, '80.	Laing, Geo.,	1004 Penn Ave., Pittsburg, Pa.
Nov. 20, '88.	Langley, J. W.,	136 First Ave., Pittsburg, Pa.
May 19, '85.	Lauder, Geo.,	48 Fifth Ave., Pittsburg, Pa.
June 19, '88.	Lean, D. R.,	Lean & Blair, Engineers and Contractors, Pittsburg, Pa.
Jan. 17, '88.	Leech, Louis D.,	44th St. and Centre Ave., Pittsburg, Pa.
Apr. 15, '84.	Leishman, John A. G.,	Lewis Block, Pittsburg, Pa.
May 16, '80.	Leschorn, Alex.,	M. E., Phœnix Bridge Co., Phœnixville, Pa.
Mar. 16, '80.	Lewis, J. L.,	Lewis Foundry and Machine Co., Ltd., Pittsburg, Pa.
Apr. 20, '80.	Lewis, W. J.,	Linden Steel Co., Pittsburg, Pa.

Date of Membership.		
May 20, '90.	Lewis, H. J.,	Keystone Bridge Co., Pittsburg, Pa.
Feb. 21, '82.	Lindenthal, Gustave,	Engineer, Lewis Block, Pittsburg, Pa.
Oct. 16, '88.	Linkenheimer, A. E.,	141 Federal St., Allegheny.
Sept. 16, '84.	Lloyd, Henry,	Iron Mfr., H. Lloyd, Sons & Co., Pittsburg, Pa.
May 19, '81.	Lloyd, John W.,	Iron Mfr., H. Lloyd, Sons & Co., Pittsburg, Pa.
Nov. 18, '90.	Lobingier, J. E.,	Braddock, Pa.
Oct. 19, '80.	Loomis, Geo. P.,	Iron Mfr., Crescent Steel Works, Pittsburg, Pa.
Sept. 16, '90.	Ludwig, Jos.,	43 Marion St., Pittsburg, Pa.
Jan. 6, '80.	Macbeth, Geo. A.,	Keystone Flint Glass Co., Pittsburg, Pa.
Apr. 19, '81.	Malone, M. L.,	Engineer, 320 Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Martin, Wm.,	Resident Eng., Davis Island Dam., P. O. Box 70, Pittsburg, Pa.
Dec. 18, '83.	Mead, Edwd.,	P. O. Box 124, Louisville, Ky.
Feb. 17, '91.	Means, E. C.,	Westinghouse Electric Co., Pittsburg, Pa.
June 18, '89.	Mellor, Walter C.,	77 Fifth Ave., Pittsburg, Pa.
Sept. 16, '90.	Mercader, Camille,	Edgar Thompson St'l Wks., Braddock, Pa.
Mar. 20, '88.	Mesta, Geo.,	Leechburg Foundry and Machine Co., Leechburg, Pa.
Jan. 6, '80.	Metcalf, Wm.,	Crescent Steel Works, 49th and R. R. Sts., Pittsburg, Pa.
Jan. 15, '84.	Meyran, L. A.,	Canonsburg Iron and Steel Co., Germania Bank Bldg., Pittsburg, Pa.

Date of Membership.		
Sept. 18, '83.	Miles, Geo. K.,	Sec. and Treas. Charlotte Fur Co., Pittsburg, Pa.
Feb. 21, '82.	Milholland, J. B.,	Engine Builder, Fifth Ave., Pittsburg, Pa.
Jan. 6, '80.	Miller, Reuben,	Crescent Steel Works, Pittsburg, Pa.
May 19, '85.	Miller, Wilson,	Sec. Pittsburg Loco. Works, 18 Lincoln Ave., Allegheny, Pa.
Oct. 19, '80.	Milliken, A. C.,	Pottsville Iron and Steel Co. Pottsville, Pa.
Apr. 19, '81.	Moorhead, M. K.,	Moorhead-McClean Co., Pittsburg, Pa.
Mar. 15, '81.	Morgan, Jas.,	2204 Carson St., Pittsburg, Pa.
Apr. 15, '90.	Morgan, Wm.,	2 Sixth St., Pittsburg, Pa.
Oct. 19, '86.	Morris, G. W.,	P. O. Box 56, Pittsburg, Pa.
Jan. 21, '90.	Morris, H. Saunders,	Westinghouse Electric Co., Pittsburg, Pa.
May 15, '83.	Morse, H. C.,	Engineer, Edgemoor, Del.
Mar. 18, '90.	Mueller, Gustave,	78 Second St., Allegheny, Pa.
Apr. 15, '80.	Munro, R.,	Boiler Manufacturer, 23d and Smallman Sts., Pittsburg, Pa.
Mar. 16, '80.	McCandless, E.. V,	Merchant, Pittsburg, Pa.
Jan. 20, '91.	McClintock, H.,	Plummer, McClintock & Irvine, S. Ave. and Snowden St., Allegheny, Pa.
May 19, '85.	McConnell, John A.,	69 Water St., Pittsburg, Pa.
Mar. 15, '81.	McCulley, R. L.,	101 Fifth Ave., Pittsburg, Pa.
Feb. 22, '81.	McCune, John D.,	98 Fourth Ave., Pittsburg, Pa.
May 21, '89.	McDonald, John,	239 Forty-fourth St., Pittsburg, Pa.
Dec. 17, '89.	McDonald, C. J.,	314 Penn Building, Pittsburg, Pa.

Date of Membership.		
Apr. 18, '87.	McDowell, James,	Optician, Observatory Ave., Allegheny, Pa.
Oct. 21, '90.	McFarland, N. J.,	Care Jennings Bros. & Co., Pittsburg, Pa.
Dec. 16, '90.	McIntyre, J. B.,	131 Urania Ave., Greensburg, Pa.
Jan. 20, '91.	McKaig, Thos. B.,	95 Fifth Ave., Pittsburg, Pa.
Sept. 21, '80.	McKinney, J. P.,	60 Sheffield St., Allegheny, Pa.
Jan. 16, '83.	McKinney, R. M.,	Elizabeth, Pa.
Mar. 15, '81.	McLennan, Alex.,	56 Sec'nd Ave., Pittsburg, Pa.
Feb. 21, '82.	McMurtry, Geo. G.,	Pittsburg, Pa.
Feb. 17, '85.	McQuiston, Jas.,	26th and Railroad Sts., Pittsburg, Pa.
Mar. 15, '81.	McRoberts, J. H.,	400 Grant St., Pittsburg, Pa.
Apr. 15, '84.	McTighe, Jas. J.,	175 W. Carson St., S. S., Pittsburg, Pa.
Jan. 6, '80.	Naegley, John,	Eng. and Architect, Room 9, Renshaw Bldg., Liberty & 9th Sts., Pittsburg, Pa.
Jan. 19, '86.	Nevins, Richard, Jr.	Seattle, Washington.
	Nichols, T. B.,	223 Allegheny Ave., Allegheny, Pa.
Apr. 20, '80.	Nimick, F. B.,	Steel Mfr., Singer, Nimick & Co., Pittsburg, Pa.
Feb. 21, '82.	Noble, Patrick,	Pacific R. M. Co., 202 Market St., San Francisco, Cal.
Feb. 20, '83.	Paddock, Jos. H.,	Civil Engineer, Connellsville, Pa.
Nov. 18, '90.	Page, Benj.,	Monon. Con. R. R., 3d Ave. and Try St., Pittsburg, Pa.
May 21, '89.	Paine, G. H.,	Swissville, Pa.
Mar. 18, '84.	Painter, Park,	Iron Mfr., J. Painter & Sons, Pittsburg, Pa.

Date of Membership.		
Nov. 20, '88.	Palmer, W. P.,	37 Beach St., Allegheny, Pa.
Sept. 18, '88.	Park, J. G.,	Room 90, Westinghouse Bldg., Pittsburg, Pa.
Jan. 6, '80.	Parkin, Chas.,	Parnassus, Pa.
Apr. 15, '84.	Parkin, Walter F.,	136 First Ave., Pittsburg, Pa.
Feb. 22, '81.	Patterson, Peter,	National Tube Works, McKeesport, Pa.
Nov. 15, '81.	Paul, J. W.,	Verona Tool W'ks, Seventh Ave. and Liberty St., Pittsburg, Pa.
Apr. 15, '84.	Paulson, Frank G.,	Hatter, Wood St., Pittsburg, Pa.
Mar. 15, '87.	Pease, Chas. T.,	Westinghouse Electric Co., Pittsburg, Pa.
Sept. 18, '83.	Peebles, Andrew,	Architect, Schmidt & Friday Building, Pittsburg, Pa.
Jan. 6, '81.	Pettit, Robt. E.,	Penna. R. R. Co., Altoona, Pa.
Jan. 20, '80.	Phillips, F. C.,	Prof. of Chemistry, 59 Sherman Ave., Allegheny, Pa.
Jan. 16, '83.	Phipps, Henry, Jr.,	Carnegie, Phipps & Co., Ltd., Pittsburg, Pa.
Dec. 20, '81.	Porter, John C.,	Spang Steel and Iron Co., Pittsburg, Pa.
May 17, '87.	Porter, John E.,	Iron Broker, Penn and Second Sts., Pittsburg, Pa.
Jan. 16, '83.	Prentice, W. J.,	Cement, Lime & Terra Cotta, 1009 Liberty St., Pittsburg, Pa.
Apr. 17, '83.	Price, C. B.,	A. V. R. R., Pittsburg, Pa.
Dec. 18, '88.	Purves, Jas.,	Munhall, Pa.
Jan. 6, '80.	Quincy, W. C.,	Mon. Cen. R. R., 3d Ave. and Try St., Pittsburg, Pa.
Mar. 15, '81.	Ramsey, Jos., Jr.,	Asst. V.-Pres. C. C. C. I. & St. L. Ry., Cincinnati, O.

Date of Membership.		
Dec. 16, '90.	Randolf, Alfred,	53 Carson St., Pittsburg, Pa.
Jan. 20, '80.	Reed, Jas.,	Supt. W. Penn. Div. P. R.R. Allegheny, Pa.
Dec. 17, '89.	Reed, J. R.,	150 Fayette St., Allegheny, Pa.
Jan. 20, '80.	Rees, Thos. M.,	Machinist, J. Rees & Sons, Pittsburg, Pa.
June 19, '88.	Reinmann, A. L.,	Westinghouse Electric Co., Pittsburg, Pa.
May 15, '83.	Reno, Geo. E.,	90 Fourth Ave., Pittsburg, Pa.
Jan. 9, '80.	Rhodes, Joshua,	Penna. Tube Works, Pittsburg, Pa.
Jan. 6, '80.	Ricketson, John H.,	Founder, 6 Wood St., Pittsburg, Pa.
Apr. 19, '87.	Rider, Percy S.,	6 Ninth St., Pittsburg, Pa.
Apr. 15, '90.	Ritchie, Jas.,	7th Avenue Hotel, Pittsburg, Pa.
Jan. 17, '88.	Robbins, F. L.,	Penn Bldg., Pittsburg, Pa.
Jan. 7, '80.	Roberts, Thos. P.,	C. Engineer, 53 Beach St., Allegheny, Pa.
Jan. 7, '80.	Rodd, Thos.,	Penna. Co., Pittsburg, Pa.
Nov. 19, '89.	Ruhe, C. H. Williams,	102 Bluff St., Pittsburg, Pa.
Jan. 17, '88.	Ruud, Edwin,	706 Penn Ave., Pittsburg, Pa.
Apr. 15, '84.	Scaife, O. P.,	Wm. B. Scaife & Sons, Structural Iron Works, 119 First Ave., Pittsburg, Pa.
Mar. 20, 83.	Scaife, W. Lucien,	Scaife Foundry & Machine Co., Twenty-Eighth and Smallman Sts., Pittsburg, Pa.
Sept. 20, '87.	Scaife, W. Marcelin,	336 Ridge Ave., Allegheny, Pa.
Apr. 15, '90.	Scheffler, Fred. A.,	Westinghouse Electric Co., Pittsburg, Pa.

Date of Membership.		
Feb. 21, '82.	Schellenberg, F. Z.,	Elysian St., E. E., Pittsburg, Pa.
Jan. 6, '80.	Schinneller, Jacob,	M.E., Room 31, McClintock Block, Pittsburg, Pa.
Feb. 17, '85.	Schmid, Alb.,	Supt. Westinghouse Electric Co., Pittsburg, Pa.
May 15, '83.	Schook, Levi,	First Ave and Ferry Sts., Pittsburg, Pa.
Jan. 6, '80.	Schultz, A. L.,	Hiland Ave., E. E., Pittsburg, Pa.
Sept. 19, '82.	Schultz, C. J.,	Iron City Bridge Works, Pittsburg, Pa.
Nov. 15, '81.	Schwartz, F. H.,	5000 Liberty St., Pittsburg, Pa.
Mar. 18, '84.	Schwartz, J. E.,	61 Fourth Ave., Pittsburg, Pa.
Apr. 15, '90.	Scott, Chas. F.,	Westinghouse Electric Co., Pittsburg, Pa.
Feb. 17, '91.	Scott, E. K.,	Keystone Bridge Co., Pittsburg, Pa.
Sept. 16, '90.	Scott, J. B.,	122 Second Ave., Pittsburg, Pa.
Jan. 16, '83.	Seaver, J. W.,	79 Fremont St., Allegheny, Pa.
Jan. 22, '89.	Shaw, A. G.,	5268 Carnegie St., Pittsburg, Pa.
Jan. 22, '89.	Shaw, W. W.,	County Engineer's Office, Pittsburg, Pa.
Sept. 19, '82.	Sherzer, W.,	C. E., 209 Home Insurance Building, Chicago, Ill.
Nov. 24, '85.	Shultz, O. G.,	McKee's Rocks P. O., Pa.
Dec. 29, '87,	Simpson, Jas. H.,	Carnegie, Phipps & Co., Ltd. Pittsburg, Pa.
Sept. 21, '80.	Singer, Harton G.,	83 Water St., Pittsburg, Pa.
May 20, '90.	Singer, R. R.,	111 Fourth Ave., Pittsburg, Pa.

Date of Membership.		
Sept. 21, '80.	Singer, W. H.,	Singer, Nimick & Co.. Pittsburg, Pa.
Jan. 6, '80.	Slataper, Felician,	Chief Eng. Penna. Co., Pittsburg, Pa.
Jan. 21, '90.	Smith, F. S.,	Westinghouse Electric Co., Pittsburg, Pa.
Feb. 17, '80.	Snyder, Antes,	Eng. Right of Way, P.R.R., Blairsville, Pa.
Apr. 15, '84.	Snyder, W. P.,	Lewis Block, Pittsburg, Pa.
Jan. 18, '88.	Speer, B.,	Prof. of Physics, Pitts. High School, Pittsburg, Pa.
Feb. 17, '80.	Sprague, H. N.,	Porter & Co., Loco. Works, Pittsburg, Pa.
May 19, '81.	Stafford, C. E.,	Shoenberger & Co., Pittsburg, Pa.
May 19, '83.	Stevenson, David A.,	Civil Engineer, Room 6, Union Station, Pittsburg, Pa.
Jan. 19, '86.	Stevenson, W. S.,	Fairmount, W. Va.
Nov. 21, '82.	Stewart, Geo. R.,	Gas Engineer,, 43 Sixth Ave. Pittsburg, Pa.
Oct. 19, '86.	Stewart, J. H.,	Care F. F. Vandevort & Co., Lewis Blk., Pittsburg, Pa.
Jan. 6, '80.	Stillburg, J. H.,	Architect, 20 Fifth Ave., Pittsburg, Pa.
Jan. 21, '90.	Stillwell, L. B.,	Westinghouse Electric Co., Pittsburg, Pa.
Oct. 21, '90.	Stowe, H. C.,	Room 801 Penn Bldg., Pittsburg, Pa.
Jan. 6, '80.	Strobel, C. L.,	M. E., 205 LaSalle St., Chicago, Ill.
Feb. 17, '91.	Stupakoff, S. H.,	Union Switch and Signal Co., Swissvale, Pa.
Feb. 20, '83.	Swan, Robert,	Civil Eng., Allegheny Ave., Allegheny, Pa.
Apr. 19, '87.	Swenson, Emil,	Keystone Bridge Works, Pittsburg, Pa.

Date of Membership.		
Feb. 19, '84.	Taylor, B. H.,	C. E., Edgar Thompson Stl. Works, Braddock, Pa.
Apr. 20, '80.	Taylor, E. B.,	Genl. Supt. Penna Co., Pittsburg, Pa.
Dec. 16, '90.	Temple, W. C.,	408 Lewis Block, Pittsburg, Pa.
May 18, '86.	Tener, Geo. E.,	Oliver Bros. & Phillips, New Castle, Pa.
Dec. 21, '81.	Thaw, Wm., Jr.,	Hecla Coke Co., 21 Lincoln Ave., Allegheny, Pa.
Apr. 19, '89.	Thorsell, J. A.,	119 First Ave., Pittsburg, Pa.
Apr. 9, '91.	Tibbitt, C. H.,	68 Sixth Ave., Pittsburg, Pa.
Mar. 18, '91.	Tone, S. L.,	19 Jackson Building, Pittsburg, Pa.
Dec. 16, '90.	Tonnelé, Theo.,	McKeesport, Pa.
Jan. 6, '80.	Trimble, Robt.,	Penna. Co., Pittsburg, Pa.
Feb. 22, '81.	Utley, Edwd. H.,	A. V. R. R., Pittsburg, Pa.
May 19, '85.	Verner, M. S.,	Supt. Citizens' Traction Co., 939 Penn Ave., Pittsburg, Pa.
Dec. 20, '87.	Verner, Henry W.,	8 Wood St., Pittsburg, Pa.
Apr. 18, '82.	Wainwright, J.,	C. E., 111 Fourth Ave., Pittsburg, Pa.
Apr. 19, '87.	Wainwright, J. R.,	P. O. Box 264, Pittsburg, Pa.
Jan. 6, '80.	Walker, J. W.,	Forty-seventh St. and A. V. R. R., Pittsburg, Pa.
Jan. 16, '83.	Warden, C. F.,	
Jan. 6, '80.	Weeks, Jos. D.,	Editor Amer. Manufacturer, Box 1547, Pittsburg, Pa.
Apr. 19, '87.	Weiskopf, Saml. C.,	Box 732, Pittsburg, Pa.
Feb. 21, '82.	Westerman, Thos.,	Verona Tool Works, Verona, Pa
Feb. 20, '88.	White, H.,	21 Church Ave., Allegheny, Pa.
May 15, '83.	White, T. S.,	Penna. Bridge Works, Beaver Falls, Pa.

Date of Membership.		
May 18, '80.	Wickersham, S. M.,	C. Eng., Home St., Allegheny, Pa.
Oct. 19, '80.	Wickersham, Thos.,	Mill Mgr., Park Bros. & Co., Pittsburg, Pa.
Oct. 21, '90.	Wieland, C. F.,	Care Riter & Conley, Allegheny, Pa.
May 18, '86.	Wierman, Victor,	Eng. Pgh. Div. P. R. R., Pittsburg, Pa.
Jan. 21, '90.	Wigham, Wm.,	Camden, Pa.
Feb. 17, '80.	Wightman, D. A.,	Supt. Pittsburg Loco. Works, Box 76, Allegheny, Pa.
Jan. 6, '80.	Wilcox, John F.,	J. P. Witherow, Lewis Block, Pittsburg, Pa.
May 15, '87.	Wilkins, W. G.,	C. E., 244 Western Ave., Allegheny, Pa.
Jan. 19, '86.	Wilson, Howard M.,	Founder, Craig St., Pittsburg, Pa.
Jan. 18, '88.	Wilson, F. T.,	Jersey Shore, Lycoming Co., Pa.
Jan. 18, '88.	Wilson, W. R.,	811 Penn Building, Pittsburg, Pa.
Feb. 20, '88.	Winn, Isaac,	National Rolling Mill, McKeesport, Pa.
Jan. 6, '80.	Witherow, J. P.,	Eng. and Contractor, Lewis Block, Pittsburg, Pa.
Nov. 19, '89.	Wolffe, J. J. E.,	Keystone Bridge Co., Pittsburg, Pa.
Jan. 15, '84.	Wood, B. L., Jr.,	Mon. Dredging Co., 43 Sixth Ave., Pittsburg, Pa.
Sept. 21, '80.	Wood, R. G.,	Iron Mills, McKeesport, Pa.
Jan. 18, '88.	Wood, Jos.,	Genl. Supt. Transportation Pa. Lines, Pittsburg, Pa.
Jan. 18, '88.	Woods, Leonard G.,	East End Hotel, Pittsburg, Pa.
Jan. 6, '80.	Zimmerman, W. F.,	U. S. Electric Co., Newark, N. J.

CORRESPONDENTS.

Society of Arts, Boston, Mass.
Massachusetts Institute of Technology,
Department of Civil Engineering, Boston, Mass.
Boston Society of Engineers, City Hall, Boston, Mass.
Brinsmade, D. S., Sec. Conn. Assoc. of Civil
Engineers and Surveyors, Birmingham, Conn.
State Association of Engineers, Norwich, Conn.
American Scientific Society, 219 River St., Troy, N. Y.
Sibley College, Cornell University, Ithaca, N. Y.
American Society of Civil Engineers,
127 East 23d St., New York.
American Society of Mechanical Engineers,
60 Madison Ave., New York.
American Institute of Mining Engineers,
Lock Box 223, New York.
Journal of Association of Engineering Societies,
73 Broadway, New York.
Railroad and Engineering Journal, 46 Broadway, New York.
Tichnischer Verein, 210 E. Fifth St., New York.
Engineering News, Tribune Building, New York.
University of Illinois, Champaign, Illinois.
Library of Second Geological Survey of Pennsylvania,
907 Walnut St., Philadelphia, Pa.
Franklin Institute, 18 S. Seventh St., Philadelphia, Pa.
Engineers' Club of Philadelphia,
1122 Girard St., Philadelphia, Pa.
Tichnischer Verein, 106 Randolph St., Chicago, Ill.
Railway Review, Chicago, Ill.

American Engineer, Chicago, Ill.
Western Society of Engineers, 78 LaSalle St., Chicago, Ill.
Civil Engineers' Club of Cleveland, Cleveland, O.
Prof. C. N. Brown,
Sec. Ohio Society of S. and C. Engineers, Columbus, O.
Indiana Society of Civil Engineers and Surveyors,
Remington, Ind.
Engineers' Club of St. Louis, St. Louis, Mo.
Engineers' Club, Kansas City, Mo.
E. S. Cunningham, Columbia, Boone Co., Mo.
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J. M. Whitman,
Arkansas Industrial University, Fayetteville, Ark.
The Practical Mechanic, Worcester, Mass.
Liverpool Engineering Society,
Colquit St., Liverpool, England.
Iron and Steel Institute, Lombard St., London, E. C.
National Association of Builders,
164 Devonshire St., Boston, Mass.
The Technic, Ann Arbor, Mich.
Stevens Institute of Technology, Hoboken, N. J.
Engineering and Mining Journal, 27 Park Place, New York.
Journal of Society of Arts, John St., Adelphi, London, W. C.
Institution of Civil Engineering,
25 Great George St., Westminster, London, S. W.
Society of Civil Engineers,
Westminster Chambers, London, S. W.
London Patent Office, London, England.
Swedish Society of Civil Engineers, Stockholm, Sweden.
Associadad dos Engenheiros Civis Portuguezos,
Lisboa, Portuguezos.
Sociadad Cientifica Argentina, Buenos Aires, S. A.
Club de Engenharia, Rio de Janeiro, Brazil, S. A.
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Wellington, New Zealand.
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Washington, D. C.
American Institute Electrical Engineers,
5 Beekman St., New York.
Smithsonian Institution, Washington, D. C.
American Journal of Railway Appliances,
113 Liberty St., New York.
The Technical Society of the Pacific Coast,
408 California St., San Francisco, Cal.
California State Mining Bureau.
Svenska Teknologforeningen, Stockholm, Sweden.